JSC “ATOMSTROYEXPORT”

**Technical specification of safe operation**

RELATED TO organization of activities   
on bnpp-1 COMMISSIONING

**52.BU.1 0.00.AB.WI.ATEX.001**

REVISION 2

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| **Technical specification of safe operation** | **52.BU.1 0.00.AB.WI.ATEX.001** | |

JSC “ATOMSTROYEXPORT”

directorate of bnpp-1 under construction

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REVISION 2

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| **AGREED BY:**  JSC «Atomenergoproekt»  Letter No.02-710/26978/930-242 from 11.08.15  JSC OKB «Gidropress»  Letter No.044/10-92/12321 from 21.08.15  NRC «Kurchatov Institute»  Letter No.110.10-5123 from 13.05.15 | **AGREED BY:**  Deputy Chief Engineer for operation of Directorate of BNPP-1 under Construction  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ E.G. Dudar  «\_\_\_\_»\_\_\_\_\_\_\_\_\_\_\_\_\_\_2015 |

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**ABBREVIATIONS AND ACRONYMS**

**AB** Auxiliary boiler

**AC** Automatic control

**ACC** Automated chemical control

**ACL** Additional control line

**ACS** Automated control system

**AFPS** Automated fire protection system

**AFWP** Auxiliary feed water pump

**ALMS** Acoustic leakage monitoring system

**ALT** Automatic load transfer

**AO** Axial offset

**APC** Automatic (reactor) power controller

**APCS** Automated process control system

**APP** Accelerated preventive protection

**APRMS** Automated process radiation monitoring system

**AR** Absorbing rods

**ARLCS** Automated residual life control system

**ARMS** Automated radiation monitoring system

**ARSMS** Automated radiation situation monitoring system

**ASS** Automatics of sequential startup

**AST**  Auxiliary standby transformer

**AT** Auxiliary transformer

**AWT** Active water treatment

**BAR** Burnable absorbing rod

**BAS** Boric acid solution

**BCS** Boron control system

**BRU-A** Quick-acting relief device for steam discharge into atmosphere

**BRU-K** Quick-acting relief device for steam discharge into condenser

**BRU-SN** House steam supply valve

**c.c.** Cold condition

**CAS** Complex analysis system

**CEP** Chief engineer of the plant

**CFP**  Condensate-feeding path

**CFSR** Compact fuel storage racks

**CH** Central hall

**CK** Control key

**CMS** Control and monitoring system

**CPS EE** CPS electric equipment

**CPS** Control and protection system (of the reactor)

**CR** Control rod

**CSS** Control safety system

**DADS** Defective assemblies detection system of

**DBE** Design basis earthquake

**DCEO** Deputy chief engineer on operation

**DD** Detecting device

**DE** Duty engineer

**DG** Diesel-generator

**DNBR** Departure from nuclear boiling ratio

**DU** Detecting unit

**DW** Demineralized water

**ECCS** Emergency core cooling system

**ECR** Emergency control room (of the unit)

**ED** External device

**EFWP** Emergency feed water pump

**EP** Emergency protection (of the reactor)

**EPCS** Electrical part of the control system

**EPSS** Emergency power control system

**ERV** Emergency regulation valve (of the turbine)

**ESFAS** Engineered safety features actuation system

**ESFIP** Engineered safety features initiating part

**FA** Fuel assembly

**FCIM** Fuel cladding inspection monitoring

**FE** Fuel element

**FFS** Fresh fuel storage

**FWP** Feed water pump

**GCK**  CPS CR group control key

**GICC** Group and individual control circuit

**HA** Hydraulic accumulator

**HL** House-load of the Unit

**HPCS** Hydraulic part of the control system

**HPH** High pressure heater

**HS** Hydraulic snubbers

**HT** Hydraulic testing

**I&C** Instrumentation and control, control and monitoring systems

**IC** Individual control

### **ICD** Independent condensate demineralizer

**ICDS** In-core detectors system

**ICI** In-core instrumentation

**ICIS** In-core instrumentation system

**ICK** CPS CR individual control key

**IRG**  Inert radioactive gases

**ISC** Inter-sealing cave (of flanged connection)

**ISP** Individual selection panel

**IVP** Inter-vessel pit

**LBB** Leak before break

**LIE** Level indicating equipment

**LLN** Long-life nuclides

**LMS** Leakage monitoring system

**LMS-H** Leakage monitoring system by humidity

**LP** Logical part

**LPH** Low pressure heater

**LSS** Localizing safety system

**LSS** Lower stop switch

**MBF** Mixed bed filter

**MCC** Main circulation circuit

**MCDS** Monitoring, control and diagnostics system (of the reactor)

**MCL** Minimally-controlled level (of power)

**MCP** Main circulation pipeline

**MCR** Main control room

**MSGV** Main steam gate valve

**MSH** Main steam header

**MSIV** Main steam isolation valve

**MSR** (neutron flux) monitoring system at (the reactor core) refueling

**MV** Main valve

**NC** Natural circulation

**NFME** Neutron flux monitoring equipment

**NFSD** Nuclear Safety Fuel Department

**NFTLMC** Neutron flux temperature and level measuring channel

**NFTMC** Neutron flux temperature measuring channels

**Nnom** Nominal power

**NOC** Normal operation conditions

**NOS** Normal operation systems

**NPC** Neutron-physics characteristics

**NPP** Nuclear power plant

**NSSS** Nuclear steam supply system

**OI** Operating instruction

**OM** Operation manual

**PCP** Process control points

**PED** Pitch electromagnetic drive

**PI** Protections and interlocks

**PP** Preventive protection

**PPD** Pulse-preventive device

**PPI** Process protections and interlocks

**PPPE** Process parameters protection equipment

**PPS** Pitch position sensor

**PPV** Pulse-preventive valve

**PR** Permissible release

**PRZ** Pressurizer

**PT** Primary transducer

**PTU** Protective tubes unit (of the reactor)

**PUR** Power unloading and restriction

**PV** Pulse valve

**RCPS** Reactor coolant pump set

**RCU** Remote control unit

**RD** Regulatory documentation

**RI** Reactor internals

**RL**  Reference level

**RM** Refueling machine

**RMJ** Reactor main joint

**RMS** Reactor monitoring system

**ROM** Reactor power limiter

**RP** Reactor plant

**RT** Relief tank

**RVI IW** Inspection well of reactor vessel internals

**SB** Storage Battery

**SFA** Spent fuel assembly

**SFP** Spent fuel pool

**SG** Steam-generator

**SGT** Special gas treatment

**SGV**  Shut-off gate valve

**SHWC** Soft-and hardware complex

**SIS** Systems important to safety

**SLPE** Signal logical processing equipment

**SOC** Safety operation condition

**SPM** Scheduled preventive maintenance

**SPND** Self-powered neutron detector

**SS APCS** Shift supervisor of APCS

**SS** Safety system(s)

**SSE** Safe shutdown event

**SSRC** Shift supervisor of the reactor compartment

**SSU** Shift supervisor of the unit

**SV** Safety valve

**SVO-1** Non-cooled coolant treatment system ТС60-90

**TC** Thermo-couple

**TEH** Tube electric heaters

**TG** Turbine-generator

**TM** Temperature monitoring

**TPE** Transportation-and process equipment

**TPS** Transportation packing set

**TPTS** Set of software-hardware facilities

**TU** Technical conditions

**UDP** Unit demineralizing plant

**UPS** Uninterruptible power supply source

**USS** Upper stop switch

**UT** Ultrasonic test

**UU** Upper unit (of the reactor)

**VMS** Vibration monitoring system

**WC** Water chemistry

# GENERAL

* 1. The technical specification has been developed in compliance with the requirements of the General Provisions for Nuclear Power Plant Safety Assurance OPB-88/97 and it is the main document defining NPP Unit safety operation.
  2. The technical specification contains the rules and the main methods of NPP Unit safety operation, general sequence of performing the operations related to safety, as well as limits and conditions of safety operation.
  3. The technical specification has been developed based on the design and BNPP-1 preliminary and final safety analysis reports.
  4. Any changes to the technical specification shall be introduced to the notifications on changes which shall be agreed upon by the organizations who agreed this specification, and approved by the operating organization and regulating authority as per the established procedure.
  5. Based on the technical specification, the Operating Instructions for the system and equipment shall be developed. The Operating Instructions for the system and equipment shall not be in contradiction to the requirements of the technical specification.
  6. By putting this Technical Specification into force, validity of technical specification of safe operation of BNPP-1 51.BU.1 0.00.AB.WI.ATEX.001 revision 0 is cancelled.
  7. Validity period of this Technical Specification is established as equal to 5 years from the date of its putting into force, after that the Technical Specification text shall be revised.
  8. The gage values of pressures in the primary and secondary circuits are specified in this specification, except for the specially specified cases.
  9. Chief technologist is responsible for this document revising and introducing changes thereto.

# MAIN DEFINITIONS AND DESCRIPTION OF NPP UNIT OPERATIONAL CONDITIONS

**2.1 The main definitions**

2.1.1 ACCIDENT – disturbance in NPP operation at which release of the radioactive materials and/or ionizing radiation occurred beyond the limits envisaged in the design for normal operation, in the amounts exceeding the established safe operation limits. The accident is characterized by the initial event, proceeding ways and the consequences.

2.1.2 READINESS FOR OPERATION – a feature of a system (element) to be capable to perform any required function at the defined conditions at present moment or within the defined period of time, if the required external resources are provided.

2.1.3 DEFECT OF A SYSTEM (ELEMENT) – every individual incompliance of a system (element) to the established requirements.

* + 1. TEST OF A SYSTEM (ELEMENT) - Experimental determination of qualitative and (or) quantitative system (element) characteristics as the result of effect to it during its functioning, simulation and (or) actuation.

2.1.5 COMPENSATORY LEAK – a leak at which the design functioning of the normal operation systems is sufficient for reliable cool down of the reactor core and controlled RP changeover to “cold” condition.

2.1.6 SHORT-TIME NPP UNIT SHUTDOWN – NPP unit shutdown for the period not more than three days.

2.1.7 TEST SUCCESSFUL COMPLETION CRITERIA – Complex of characteristics based on which serviceability of a system (element) may be confirmed.

2.1.8 FALSE EP OR PPI ACTIVATION – activation caused by malfunction of the elements or their circuits. At the false activation, the actual values of the relevant parameters do not reach the values of their setpoints.

2.1.9 MINIMALLY CONTROLLED LEVEL (MCL) OF THE REACTOR POWER – the reactor power level within the range from 10-5 to 1 % of the nominal one, sufficient to control for the chain reaction by means of the standard control equipment (NFME). MCL is considered to be reached, if using NFME the power level as 10-5 % of the nominal one is recorded.

* + 1. MAXIMUM PERMISSBLE REACTOR THERMAL POWER (Nperm) – design thermal power corresponding to the operational limits and conditions defined in the design.
    2. ANTICIPATED OPERATIONAL OCCURENCE – disturbance in NPP Unit operation at which deviation from the established operational limits and conditions occurred. At the same time, the other design-envisaged limits and conditions may be violated including the safe operation limits.
    3. EP CHANNEL MALFUNCTION – is a failure of the equipment in the channel which does not cause safety function failure in this channel.
    4. PP CHANNEL MALFUNCTION – is a failure of the equipment in the channel which does not cause safety function failure in this channel.
    5. NON-COMPENSATROY LEAK – a leak at which the designed functioning of the normal operation systems is not sufficient to compensate coolant losses and the automatic activation of safety systems is required.
    6. NOMINAL REACTOR THERMAL POWER (Nnom) – thermal power of the reactor at four running RCPS and normal condition of the equipment amounting to 3000 MW.
    7. NORMAL OPERATION – NPP unit operation without deviations from the established limits and conditions, as well as all activities intended to reach the objective for which the NPP was constructed in a safety way including operation at power, startup, shutdowns, tests, maintenance, repair and refueling, inspections during operation and other associated activities.
    8. NPP UNIT SHUTDOWN – the reactor change over to the sub-critical state. The shutdown may be scheduled as per the preliminary agreed program or unscheduled.
    9. EP CHANNEL FAILURE – is failure of the equipment in the channel causing failure of functioning in this channel.
    10. FAILURE OF ONE EP EXECUTIVE PART SET – is a failure in EP executive part equipment causing reliability reducing or failure in EP functioning in this set.
    11. PP CHANNEL FAILURE – is a failure of the equipment in the channel causing failure of functioning in this channel.
    12. FAILURE OF A SYSTEM (ELEMENT) – an event consisting in disturbance of the serviceable condition of a system (element).
    13. CORE REFUELING – nuclear-hazardous works on FA, CPS AR and BAR bundles loading, extraction and removal in order to replace the spent ones.

2.1.23 PRE-EMERGENCY SITUATION – NPP unit condition characterized by violation of safe operation limits or conditions which has not developed to an accident.

2.1.24 SAFE OPERATIONAL LIMITS – process parameters established by the design deviations from which may cause an accident.

* + 1. DESIGN LIMITS – values of parameters and characteristics of systems (elements) conditions and NPP as a whole established in the design for normal operation, emergency situations and accidents.
    2. NPP UNIT STARTUP - a set of operations on bringing the reactor to the critical state and NPP Unit changeover to the energy level of power. NPP Unit startup shall be started from taking up the reactor CPS control rods to the operating position and completed by power switching of the turbine-generator.
    3. STARTUP RANGE – the range of boric acid content values in MCC water for a certain RP condition at which the reactor is expected to reach the critical state. The lower value of the interval shall be taken as equal to the design value of the boric acid contents corresponding to the critical state. The upper value of the interval shall be taken as equal to the lower one increased to 1 g/kg.
    4. SERVICEABLE CONDITION – condition of a system (including auxiliary elements), at which values of all parameters characterizing capability to perform the defined functions corresponds to the requirements of the regulatory and (or) design documentation.
    5. PRIMARY CIRCUIT UNSEALING – a set of operations on removing the sealing from at least one primary circuit joint.
    6. REPAIR - set of operations on recovery of serviceability or serviceable state of an object and (or) recovery of its lifetime.
    7. NPP UNIT HEAT-UP – totality of operations at the systems and equipment providing NPP Unit changeover from “cold” to “hot” condition.
    8. NPP UNIT COOL DOWN - totality of operations at the systems and equipment providing NPP Unit changeover from “hot” to “cold” condition.
    9. STEADY RP POWER LEVEL – any level of RP power within the range from MCL up to the nominal one at which RP has been working more than 3 hours.
    10. MAINTENANCE - set of operations for maintaining serviceability or serviceable state of an object (systems and elements) at proper use in the standby mode, during storage and transportation.
    11. FUEL LOADING – totality of FA, CPS AR and BAR bundles available in the reactor core between two sequential refueling.
    12. PRIMARY CIRCUIT SEALING – set of operations on tightening the bolt and stud joints and other works at primary circuit joints in compliance with the operational procedures in order to provide for its tightness confirmed by the relevant tests.
    13. CPS CR CONTROL GROUPS – three CPS CR groups with maximal numbers (groups No. 8,9,10 for the first loading), intended to control the reactor power and power-flux distribution in the core

2.1.38 SAFE OPERATION CONDITIONS – design-established minimal conditions on quantity, characteristics, serviceability and maintenance conditions of the systems (elements) important to safety at which safe operation limits and/or safety criteria observation is provided.

2.1.39 CONTAINMENT INTEGRITY – state of the containment structure at which the following conditions are fulfilled:

1. all hand-operated valves and plugs cutting off the containment are closed with except for those mounted at I&C pulse lines;
2. at least one door of each personnel lock is tightly closed;
3. at least one of the transportation lock doors is tightly closed;
4. at least one of two doors assembled into annulus space is tightly closed (for the main and emergency locks);
5. all containment isolation valves shall be operable, closed and motive forces are de-energized, except for the normally opened valves, with exception of the valves which are used for I&C pulse lines
   * 1. LOADING CYCLE – single changing of the operating medium parameters from the initial condition up to the final condition.
     2. OPERATIONAL LIMITS – values of parameters and characteristics of the systems (elements) condition as well as NPP as a whole defined by the design for normal operation.
     3. OPERATION WITH DEVIATIONS – NPP operation with violation of operational limits or conditions, but without violating safe operation limits or conditions
     4. NUCLEAR-HAZARDOUS ACTIVITIES – activities at RP which can cause the nuclear accident.
     5. SPIKE-EFFECT is growth of specific iodine-131 radionuclide activity I the coolant of the primary circuit 5 and more time, related to emission of this radionuclide from non-tight fuel elements after actuation of RP emergency protection system or after changing RP power not less than 20 % from the current level. Spike-effect shall be defined on the basis of special methods, which is described in OI for FCIM.

**2.2 Operational conditions of NPP Unit**

**2.2.1 Operating modes of NPP Unit normal operational conditions**

During operation NPP Unit can be in one of the following modes:

1) “operation at power”:

a) with full number of RCPS;

b) with incomplete number of RCPS;

2) “the reactor is at the minimally controlled level of power”;

3) “hot” condition;

4) “cold” condition;

5) “shutdown for repair”;

6) “refueling”.

During change over from one mode to another, NPP Unit is in the transient mode.

**2.2.2 RP parameters in NPP Unit normal operation conditions**

**2.2.2.1 NPP operation mode “Operation at power” (condition 1)**

NPP operation mode “operation at power” is characterized by the following conditions and parameters:

1) the reactor power is within the range from 1.0% to 100 % of the nominal level;

2) boric acid concentration in the primary circuit coolant is current, corresponding to the reactor power and CPS CR position;

3) primary circuit coolant temperature:

а) in “cold” legs – not more than 291+2 °С;

б) in “hot” legs – not more than 321+5 °С;

4) primary circuit pressure - (15,7±0,3) MPa (160±3 kgf/cm2);

5) PRZ level - ((5100÷8170)±150) mm (level calculation from the bottom internal generatrix of PRZ shell);

6) SG pressure - (6,27±0,1) MPa (64±1,02 kgf/cm2);

7) SG level - (2400±50) mm;

8) at least two RCPS are in operation:

а) four RCPS – at operation with the full number of the circulating loops;

b) two or three RCPS – at operation with incomplete number of the circulating loops;

9) CPS CR position is in compliance with Appendix E;

10) the turbine plant is in hot standby at nominal speed (3000 rpm) and connected to the external network system (depending on RP power).

#### 2.2.2.2 NPP operation mode “the reactor is at the minimally-controlled level of power” (condition 2)

NPP operation mode “the reactor is at the minimally-controlled level of power” is characterized by the following conditions and parameters:

1) reactor is critical;

2) reactor power is within the range from10-5 to 1.0 % Nnom;

3) boric acid concentration in the primary circuit coolant is current, corresponding to the critical state;

4) primary circuit coolant temperature – more than 260 °С;

5) PRZ level - (5100±150) mm;

6) primary circuit pressure - (15,7±0,2) MPa (160 ±2) kgf/cm2;

7) at least two RCPS are in operation;

8) SG pressure – (4,9÷6,28) MPa (50÷64) kgf/cm2;

9) SG level - (2400±50) mm;

10) CPS CR position is in compliance with Appendix E;

11) the turbine plant is non-cooled condition on BG (barring gear).

#### 2.2.2.3 NPP Unit mode “Hot condition” (condition 3)

NPP Unit “hot condition” is characterized by the following conditions and parameters:

1) the reactor is sub-critical, the sub-criticality margin is not less than 1 % dk/k over the sub-criticality introduced by CPS CR, boric acid concentration in the primary circuit coolant is not less than minimally permissible one in compliance with that of specified in NPC album, specific for every loading;

2) CPS CR is on LSS or on the fixed stops;

3) primary circuit coolant temperature – more than 260 °С;

4) primary circuit coolant pressure – (15,7±0,2) MPa (160±2) kgf/cm2;

5) PRZ is in the steam mode;

6) PRZ level - (5100±150) mm;

7) SG pressure – (4,9÷6,28) MPa (50÷64 kgf/cm2);

8) SG level - (2400±50) mm;

9) at least 2 opposite RCPS are in operation.

10) the turbine plant is non-cooled condition on BG (barring gear).

#### 2.2.2.4 NPP Unit mode “Cold condition” (condition 4)

NPP Unit mode “cold condition” is characterized by the following conditions and parameters:

1) the reactor is sub-critical, boric acid concentration in primary circuit coolant is not less than 16 g/dm3;

2) CPS CR is on LSS or on the fixed stops;

3) coolant temperature at the core top is not more than 70 °С;

4) primary circuit coolant pressure is not more than 2,0 MPa (20 kgf/cm2);

5) TH system is in operation for the core residual heat removal;

6) the primary circuit is sealed;

7) minimal PRZ level is 5700 mm;

8) non-exceeding of the difference between the temperature of the coolant supplied from TH system to the core bottom and coolant temperature 30 0С at the core top is provided;

9) the turbine plant is in cold condition

#### 2.2.2.5 NPP Unit mode “shutdown for repair” (condition 5)

NPP Unit mode “shutdown for repair” is characterized by the following RP conditions and parameters:

1) the reactor is sub-critical;

2) CPS CR is on LSS or on the fixed stops;

3) boric acid concentration in the primary circuit coolant – not less than 16 g/dm3;

4) coolant temperature at the core top is less than 70 °С;

5) primary circuit pressure is equal to the atmospheric one;

6) PRZ temperature is less than 70 °С;

7) level in the reactor is (200÷300) mm below RMJ or reduced to perform the repair works but not lower than the upper constitutive cold nozzles of the reactor;

8) the primary circuit is unsealed;

9) TH system is in operation by the normal or maintenance cool down circuit;

10) non-exceeding of the difference between the temperature of the coolant supplied from TH system to the core bottom and coolant temperature 30 0С at the core top is provided.

11) Volume under the reactor top head shall be vented by nitrogen at three drives removed. At SG headers unsealing, volume of headers shall be vented by nitrogen;

12) Turbine plant is in cold condition. (It is allowed to perform maintenance works).

#### 2.2.2.6 NPP Unit mode “refueling” (condition 6)

NPP Unit mode at “refueling” is characterized by the following RP conditions and parameters:

1) the reactor is sub-critical;

2) boric acid concentration in the primary circuit coolant, in the spent fuel pool – not less than 16 g/dm3;

3) coolant temperature at the core top – less than 70 °С, and in the spent fuel pool at works conduction: 50 °С – at the scheduled refueling, 70 °С – at the complete unloading of the core FA to the spent fuel pool;

4) primary circuit pressure is equal to the atmospheric one;

5) level in FP (container section, reactor internals inspection cavity, upper reactor cavity) is not lower the elevation +21,0 m;

6) non-exceeding of the difference between the temperature of the coolant supplied from TH system to the core bottom and coolant temperature 30 0С at the core top is provided;

7) Turbine plant is in cold condition, maintenance works are performed.

#### 2.2.3 Characteristics of the turbine plant in the power unit operational conditions

#### 2.2.3.1 “Cold” condition of the turbine generator – The turbine body metal temperature in steam-admission zone does not exceed 80 oС.

#### 2.2.3.2 “Non-cooled” condition of the turbine generator – the turbine body metal temperature in steam-admission zone is from 80 °С to 180 °С.

#### 2.2.3.3 «hot» standby of the turbine generator - the turbine body metal temperature in steam-admission zone is more than 180 °С.

# 3 DESIGN LIMITS FOR THE UNIT OPERATION

**3.1 Safety criteria**

#### 3.1.1 The reactor core as well as the associated coolant system of the reactor is designed with the relevant margin to provide for non-exceedance of the defined permissible design limits at any operational conditions as well as under effect of the events expected during operation.

#### 3.1.2 In general, depending on the operation sphere the design limits have the following classification:

* operational limits;
* safe operation limits;
* maximal design limits.

#### 3.1.3 For normal operation conditions, the operational limit is established for FE damage due to formation of micro-cracks with the defects such as gaseous leakiness of the cladding, which shall not exceed 0,2 % of FRs and 0,02 % of FRs at the direct contact of the nuclear fuel with the coolant.

#### 3.1.4 Non-exceedance of the operational limits in the core is provided by maintaining RP parameters within the design limits by means of control and monitoring systems of normal operation (APC, ROM, APP, PP, SGIC).

#### 3.1.5 For normal operation conditions and at disturbances of normal operation condition, safety operation limit is established by quantity and size of FE - 1 % of FRs with the defects such as gaseous leakiness and 0,1 % of FRs for which the direct contact of the coolant and nuclear fuel is available in the modes of normal operation disturbance (taking into regard functioning of the protective systems):

* at malfunctioning of the reactor control and monitoring system;
* at RCPS power supply loss;
* at tripping the turbine-generators and heat consumers;
* at complete loss of the external power supply sources;
* at primary circuit leakages compensatory and non-compensatory by the primary circuit makeup systems.

#### During design basis accidents (taking into regard functioning of the emergency core cooling system) the maximum limit of FE damage is not exceeded:

* fuel cladding temperature is not more than 1200 °С;
* local oxidation depth of the fuel cladding is not more than 18 % of the initial wall thickness;
* fraction of the reacted zirconium is not more than 1 % of its mass in the fuel claddings.

#### The values of the reactivity coefficients by the coolant specific volume, by coolant temperature, by fuel temperature and by the reactor power are negative within all range of the reactor parameters variations at normal operation, disturbances in normal operation and design accidents.

#### 3.1.6 The reactor core structure jointly with the non-interruptible power supply system, CPS, ECCS, interlocks eliminates the possibility of the core disruption and fuel melting in all design modes and allows to perform the reactor core unloading in the specified modes.

#### 3.1.7 Maximal linear thermal flux from FRs in normal operation modes shall not exceed the limit values at the bottom half of the core height - 448 W/cm, in the top half of the core – linear decreasing with the intermediate value 360 W/cm at the height as 80 % of the core bottom taking into account errors of the defined parameters.

Basic setpoints of EP, PP-1, PP-2 for the linear energy release for the different number of operating RCPS at energy reactor power levels are specified below. In case of changing the number of operating RCPS, the time delay of 80 seconds gets actuated in SHWC-3 equipment to apply reduction factors to setpoints of the linear energy release.

Table 3.1.1 Setpoints of EP, PP-1, PP-2 for the local energy release (qL).

Totally, 4 RCPS are in operation.

|  |  |  |
| --- | --- | --- |
| **Setpoint of EP for qL [W/cm]** | | |
| Layer No. | Fuel elements of the marginal row in FA | Other fuel elements |
| 1 | 392.0 | 420.0 |
| 2 | 392.0 | 420.0 |
| 3 | 392.0 | 420.0 |
| 4 | 387.6 | 415.3 |
| 5 | 355.3 | 380.6 |
| 6 | 318.5 | 341.3 |
| 7 | 280.9 | 300.9 |
| **Setpoint of PP-1 for qL [W/cm]** | | |
| Layer No. | Fuel elements of the marginal row in FA | Other fuel elements |
| 1 | 373.3 | 400.0 |
| 2 | 373.3 | 400.0 |
| 3 | 373.3 | 400.0 |
| 4 | 369.2 | 395.5 |
| 5 | 338.3 | 362.5 |
| 6 | 303.3 | 325.0 |
| 7 | 267.5 | 286.6 |

Continuation of Table 3.1.1

|  |  |  |
| --- | --- | --- |
| **Setpoint of PP-2 for qL [W/cm]** | | |
| Layer No. | Fuel elements of the marginal row in FA | Other fuel elements |
| 1 | 369.6 | 396.0 |
| 2 | 369.6 | 396.0 |
| 3 | 369.6 | 396.0 |
| 4 | 365.5 | 391.6 |
| 5 | 335.0 | 358.9 |
| 6 | 300.3 | 321.8 |
| 7 | 264.8 | 283.7 |

Table 3.1.2 Setpoints of EP, PP-1, PP-2 for the local energy release (qL).

Totally, 3 RCPS are in operation.

|  |  |  |
| --- | --- | --- |
| **Setpoint of EP for qL [W/cm]** | | |
| Layer No. | Fuel elements of the marginal row in FA | Other fuel elements |
| 1 | 297.9 | 319.2 |
| 2 | 297.9 | 319.2 |
| 3 | 297.9 | 319.2 |
| 4 | 294.6 | 315.6 |
| 5 | 270.0 | 289.3 |
| 6 | 242.1 | 259.4 |
| 7 | 213.5 | 228.7 |
| **Setpoint of PP-1 for qL [W/cm]** | | |
| Layer No. | Fuel elements of the marginal row in FA | Other fuel elements |
| 1 | 283.7 | 304.0 |
| 2 | 283.7 | 304.0 |
| 3 | 283.7 | 304.0 |
| 4 | 280.6 | 300.6 |
| 5 | 257.1 | 275.5 |
| 6 | 230.5 | 247.0 |
| 7 | 203.3 | 217.8 |

Continuation of Table 3.1.2

|  |  |  |
| --- | --- | --- |
| **Setpoint of PP-2 for qL [W/cm]** | | |
| Layer No. | Fuel elements of the marginal row in FA | Other fuel elements |
| 1 | 280.9 | 301.0 |
| 2 | 280.9 | 301.0 |
| 3 | 280.9 | 301.0 |
| 4 | 277.8 | 297.6 |
| 5 | 254.6 | 272.7 |
| 6 | 228.2 | 244.5 |
| 7 | 201.3 | 215.6 |

Table 3.1.3 Setpoints of EP, PP-1, PP-2 for the local energy release (qL).

Totally, 2 adjacent RCPS are in operation.

|  |  |  |
| --- | --- | --- |
| **Setpoint of EP for qL [W/cm]** | | |
| Layer No. | Fuel elements of the marginal row in FA | Other fuel elements |
| 1 | 180.3 | 193.2 |
| 2 | 180.3 | 193.2 |
| 3 | 180.3 | 193.2 |
| 4 | 178.3 | 191.0 |
| 5 | 163.4 | 175.1 |
| 6 | 146.5 | 157.0 |
| 7 | 129.2 | 138.4 |
| **Setpoint of PP-1 for qL [W/cm]** | | |
| Layer No. | Fuel elements of the marginal row in FA | Other fuel elements |
| 1 | 171.7 | 184.0 |
| 2 | 171.7 | 184.0 |
| 3 | 171.7 | 184.0 |
| 4 | 169.8 | 181.9 |
| 5 | 155.6 | 166.8 |
| 6 | 139.5 | 149.5 |
| 7 | 123.1 | 131.8 |

Continuation of Table 3.1.3

|  |  |  |
| --- | --- | --- |
| **Setpoint of PP-2 for qL [W/cm]** | | |
| Layer No. | Fuel elements of the marginal row in FA | Other fuel elements |
| 1 | 170.0 | 182.2 |
| 2 | 170.0 | 182.2 |
| 3 | 170.0 | 182.2 |
| 4 | 168.1 | 180.1 |
| 5 | 154.1 | 165.1 |
| 6 | 138.1 | 148.0 |
| 7 | 121.8 | 130.5 |

Table 3.1.4 Setpoints of EP, PP-1, PP-2 for the local energy release (qL).

Totally, 2 opposite RCPS are in operation.

|  |  |  |
| --- | --- | --- |
| **Уставка АЗ по qL [Вт/см]** | | |
| Layer No. | Fuel elements of the marginal row in FA | Other fuel elements |
| 1 | 231.3 | 247.8 |
| 2 | 231.3 | 247.8 |
| 3 | 231.3 | 247.8 |
| 4 | 228.7 | 245.0 |
| 5 | 209.6 | 224.6 |
| 6 | 187.9 | 201.3 |
| 7 | 165.7 | 177.6 |
| **Setpoint of PP-1 for qL [W/cm]** | | |
| Layer No. | Fuel elements of the marginal row in FA | Other fuel elements |
| 1 | 220.3 | 236.0 |
| 2 | 220.3 | 236.0 |
| 3 | 220.3 | 236.0 |
| 4 | 217.8 | 233.4 |
| 5 | 199.6 | 213.9 |
| 6 | 179.0 | 191.8 |
| 7 | 157.8 | 169.1 |

Continuation of Table 3.1.4

|  |  |  |
| --- | --- | --- |
| **Setpoint of PP-2 for qL [W/cm]** | | |
| Layer No. | Fuel elements of the marginal row in FA | Other fuel elements |
| 1 | 218.1 | 233.6 |
| 2 | 218.1 | 233.6 |
| 3 | 218.1 | 233.6 |
| 4 | 215.6 | 231.0 |
| 5 | 197.6 | 211.7 |
| 6 | 177.2 | 189.8 |
| 7 | 156.2 | 167.4 |

#### 3.1.8 Departure from nuclear boiling ratio (DNBR) in the core taking into account the error of its determination in modes with anticipated operational occurrences at confidence probability 95 % shall be not less than 1,0 taking into account the errors of the determined parameters.

ICIS software and application software related to departure from nuclear boiling ratio determination shall be verified according to ICIS operating instructions, including comparison with results of calculations by codes used for RP design justification. By verification results, DNBR setpoints for steady and unsteady modes shall be as follows:

- EP - 1.2;

- PP-1 - 1.3;

- PP-2 - 1.35;

#### 3.1.9 The safety criteria defining the integrity of the reactor coolant system is non-exceedance of the pressure value to more than 15 % of the operating pressure value.

#### The specified safety criteria is the safety operation limit for the primary circuit coolant system.

#### All range of pressure increasing from the nominal one up to the safety operation limit has a number of setpoints on pressure upon reaching the values of which the process protections shall be activated to prevent pressure increasing over the operational limits established by the design, or the safety systems shall be activated in case of exceeding the operational limits by pressure, to mitigate the emergency condition consequences and prevent against reaching the safety operation limit.

#### Non-exceedance of the operational limits by pressure in all spectrum of NOC modes is provided by the pressurizing system.

3.1.10 RP design shows non-exceedance of the following safety criteria:

- power fluctuation rates shall not exceed the values specified in Table 3.2.1.6.1;

- maximal efficient time of FA operation in the core depends on fuel enrichment value;

- maximal calendar time of FA being in the core is 5 years;

- maximal deviation of offset current state from its steady value is 5 %. Steady offset value is the offset value established at the reactor operation at nominal power;

- reactivity coefficient by coolant specific volume, coolant and fuel temperature and the reactor power is negative within all range of the reactor parameters variation;

- minimal efficiency of the emergency protection at Nnom, at the beginning and the end of fuel loading operation, not less that the value defined in NPC album for this specific loading;

- recriticality temperature is not more than 120 °С;

- maximal power of the reactor at RCPS switching – at three running ones it is 30 % Nnom, at two running ones it is 20 % Nnom.

**3.2 Operational limits**

**3.2.1 Operational limits by process parameters**

#### 3.2.1.1 In Table 3.2.1.1.1 the process parameters are given for the unit condition “operation at power” for normal operation.

Table 3.2.1.1.1 – Process parameters in condition “operation at power ” for normal operation

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Parameters** | **Number of RCPS running** | | | | **Accuracy of determination** |
| **4** | **3** | **2**  **opposite loops** | **2**  **adjacent loops** |
| 1 Maximally permissible thermal power of the reactor (taking into account accuracy of maintaining by the control system), MW/%Nnom | 3000+60  100+2 | 2010+60  67+2 | 1500+60  50+2 | 1200+60  40+2 | ±60/2 |
| 2 Defined (permissible) power, MW / % | 3000/100 | 2010/67 | 1500/50 | 1200/40 | ±60/2 |
| 3 Coolant heating in the reactor (in every circulation loop), max., °С | 32,5 | 25,5 | 26,5 | 21,5 | ±0,5 |
| 4 Pressure differential at the reactor without taking into consideration the nozzles, MPa | 0,381±0,06 (at 4 running RCPS and flow-rate 84800 m3/hr) | | | | |
| 5 Coolant temperature at the reactor top, °С, not more than | 325 | 316 | 317 | 310 | ±1 |
| 6 Maximal coolant temperature at FA outlet, °С not more than | 335 | 333 | 338 | 330 | ±1 |
| 7 Reactor coolant flow, m3/hr | 84800  (+4000  -4800) | 64000  (+1700  -2400) | 40700  (+1250  -1750) | 40700  (+1250  -1750) |  |
| 8 Coolant temperature at the reactor bottom, °С, not more than | 292 | 290 | 290 | 288 | ±1 |
| 9 Coolant pressure at the reactor top, MPa (kgf/cm2) | 15,7±0,2 (160±2) | | | | ±0,1 (1) |
| 10 Steam pressure in running SG at the steam header outlet not more than, MPa (kgf/cm2) | 6,27±0,05 (64±0,5) | | | | ±0,05 (0,5) |

#### 3.2.1.2 APC shall be calibrated by weighted average value of thermal power calculated by ICIS taking into account the possibility to provide for the power control error to be not more than 2 % of the nominal one.

#### 3.2.1.3 Nominal value of water level in SG shall amount (2400±50) mm as per double-chamber level-meters No. 5, 6, 7..

The nominal level is water level in the steam-generator as per the double-chamber level meter No.7, at which with the margin at least 50 mm the steam moisture at the steam-generator outlet is provided (in the steam-line) not more than 0,2 % at the steam-generator steam capacity equal to 100 %.

#### 3.2.1.4 The reactor coolant flow and SG steam flow-rate shall be defined by an indirect method. Coolant flow shall be defined by RCPS rating data and by heat balance; steam flow-rate shall be defined by feed water flow-rate taking into account the flow-rate for SG blow-down and by the heat balance as well.

#### 3.2.1.5 If the parameter values exceed the established operational limits, the operative measures shall be immediately taken to provide for correspondence to the specified limits including also reducing the reactor power, with the maximally-permissible rate specified in Table 3.2.1.6.1. If it is impossible to restore the permissible parameter values, the reactor shall be shutdown at the operating rate.

#### 3.2.1.6 Table 3.2.1.6.1 shows the permissible rates for the reactor power variation and the associated permissible number of FA loading cycles.

Table 3.2.1.6.1 - permissible rates for power variation and permissible number of FA loading cycles

|  |  |  |  |
| --- | --- | --- | --- |
| **Permissible rates for power variation** | | | **permissible number of TA loading cycles** |
| 1 POWER DOWN (except for EP, APP and PP1) | | | Number of cycles is unlimited |
| From 100% Nnom and less  Rate | up to  not more | MCL  3% Nnom /min |  |
| 2 POWER ASCENSION (excluding power ascension as per item 3) | | | 70 cycles per FA life-time |
| 2.1 From MCL  Rate | up to  not more | (40÷45)% Nnom  3% Nnom /min |  |
| 2.2 From (40÷45)% Nnom  Rate | up to  not more | (75÷85)% Nnom  1% Nnom /min |
| 2.3 At power level  Delay | not less | (75÷85)% Nnom  3 hours |
| 2.4 From (75÷85)% Nnom  Rate | up to  not more | 100% Nnom  1% Nnom /min |

Table 3.2.1.6.1, continued

|  |  |  |  |
| --- | --- | --- | --- |
| **Permissible rates for power variation** | | | **permissible number of TA loading cycles** |
| 3 POWER ASCENSION   1. after more than 12 days operation at any decreased power level 2. after refueling at more than 12 days of the reactor operation at the end of the previous cycle at the power effect of the reactivity 3. at connection of the idling loop | | | 23 cycles per FA life-time, without taking into account RCPS activation at MCL |
| 3.1 From MCL  Rate | up to  not more | 50% Nnom  3% Nnom /min |  |
| 3.2 From 50% Nnom  Rate | up to  not more | 80% Nnom  0.17% Nnom /min |
| 3.3 From 80% Nnom  Rate | up to  not more | 100% Nnom  0.017% Nnom /min |
| Average rate of power ascension within the range from 50% Nnom to 100% Nnom shall be provided by:   1. sequential power ascension to (2÷4) % Nnom 2. rate of sequential power ascension to 2% Nnom /min 3. delay between the ascension steps | | |  |
| ***Note.*** At idling loop cut-in - 23 cycles within FA lifetime per each RCPS, without taking into account RCPS connection at MCL | | | |
| 4 POWER SURGE TO 20% Ncur at load variations | | | 15 cycles per FA life-time |
| 4.1 From MCL | to | 50% Nnom |  |
| Implemented by:   1. one step 2. at rate provided by the reactor control system | | |  |
| 4.2 From 50% Nnom | to | 100% Nnom |  |
| Implemented by:   1. two steps 10% Ncur per each 2. at rate provided by the reactor control system 3. delay between the ascension steps at least 3 hours | | |  |
| Note:   1. Upon selection of the column (RP power ascension rates) the determining factor is the operation at a stable (considering measurement accuracy) low power level within 50%Nnom < Nlow < 98%Nnom 2. In case RP worked at Nlow more than 12 days, and then by some reason occurred power decrease to Ncur < Nlow and RP worked at Ncur less than 12 days, power ascension from Ncur to Nlow shall be performed according to item 2 of the table, and from Nlow to Nnom – according to item 3 of the table. 3. If in the a.m. case RP worked at the power level Ncur more than 12 days, the following variants are possible:   a) Ncur > 50%Nnom load increase from Ncur to Nnom shall be performed according to item 3 of the table;  b) Ncur < 50%Nnom load increase from Ncur to Nlow shall be performed according to item 2 o the table, and from Nlow to Nnom – according to item 3 of the table. | | | |

#### 3.2.1.7 Prior to connection of the idling loop to three (two) operating ones, the reactor power shall be decreased up to 30 (20) % Nnom respectively. The rate of power ascension after RCPS activation shall be in compliance with the third item of Table 3.2.1.6.1 up to the value defined by the second item of Table 3.2.1.1.1.

#### 3.2.1.8 Operational limits as per the power-flux variation coefficients.

#### The power flux variation coefficients by the core volume Kv(i,j), controlled by MCDS readings shall not exceed Kv max.(i,j) defined by the following ratio:

#### Kv max (i,j) = Kv nom(i,j) /(0.17+0.83Ncur./Nnom),

#### where i – a number of the core height layer with numbering from the core bottom (i =1,2,…,16);

#### j – FA number (j =1,2,…,163);

#### Kv nom(i,j) – maximally permissible Kv(i,j) value at the nominal level of the reactor power;

#### Ncur. – current reactor power;

#### Nperm – permissible reactor power,

The array of Kv nom (i,j) for charge core life shall be calculated within neutronic calculation period to substantiate safety of the current fuel column with the step for the charge core life not exceeding 40 effective days and specified in neutron physical characteristics album for each fuel element column.

Kv max maximal values shall be set in MCDS as alarm setpoint and measured automatically depending on the current value of the reactor power.

3.2.1.9 ICIS controlled value of power flux axial peaking factor – Kq at the nominal power level has a limit:

Kq ≤ Kq max,

where Kq max=1,35.

At any power level the following limit shall be fulfilled:

Kq ≤ Kq max×Ncur nom / Ncur,

where:

Ncur nom – permissible reactor power at the current value of running RCPS,

Ncur – current reactor power.

3.2.1.10 The algorithms of control for power and power-flux distribution in the core are specified in Appendix E.

3.2.1.11 The permissible values of the quality indices of the operating media in the primary and secondary circuits during the Unit operation are specified in Appendix F.

#### 3.2.2 Limits on the equipment loading conditions

#### 3.2.2.1 In the process of the Unit operation the quantity of the equipment loading cycles shall be recorded at normal operation and at disturbances in normal operation, as well as the quantity of modes and quantity of cycles for the design basis accidents which are limited by the design (see Tables 3.2.2.1.1, 3.2.2.1.2, 3.2.2.1.3).

### Table 3.2.2.1.1 – List of modes and maximally-permissible quantity of cycles for normal operation conditions

|  |  |  |
| --- | --- | --- |
| **Mode description** | | **Quantity per lifetime** |
| 1. Filling of the equipment with the operating medium, sealing of the following equipment: | |  |
|  | reactor | 100 |
|  | the other equipment | 60 |
| 2. Separate hydraulic testing of the primary and secondary circuits: | |  |
|  | for tightness | 100 |
|  | for strength | 30 |
| 3. Scheduled heat-up from cold condition at rate 20 оС/hr | | 130 |
| 4. Steady state (operation at four circulation loops at 49...50,5 Hz frequency in the network). Operation at three and two circulation loops is allowed | | unlimited |
| 5. Power variation | |  |
| 5.1. Load ascension at 60 % rate of the current power per minute within the range 0..10 % Nnom, at rate 3...4 % Nnom per minute within the range 10...70 % Nnom, at rate 1...1,5 % Nnom per minute within the range 70...100 % Nnom with 3 hour withstanding at power as 70...80 % Nnom.  Daily power ascension from house load level or from hot standby after being in these conditions within 5...8 hours daily and within 24...55 hours during nonworking days with the specified rates | | 5600 |
| 5.2. Load decreasing at the rates specified in item 5.1, daily load-shedding up to the house-load level or hot standby for 5...8 hours or for 24...55 hours in nonworking days at the same rates | | 5000 |
| 5.3. Load variation within 30...100 % Nnom (regulating range) without operation time limitation at any level of power and load creation after long-term operation within the specified range at the rates specified in item 5.1 | | 10000 |
| 5.4. Electrical load shedding by the Unit at rate 150...200 % Nnom per second up to any value from any value of initial power without limitation in operation time at new level of power at shedding from the upper to the lower limit of the regulating range | | 150 |

Table 3.2.2.1.1, continued

|  |  |  |
| --- | --- | --- |
| **Mode description** | | **Quantity per lifetime** |
| 5.5. Recovery of the electrical Unit load at rate 25...30 % Nnom per minute up to the initial value after load shedding as per item 5.4, if duration of operation at the decreased power level does not exceed 10 sec (in case of increasing duration of operation at the decreased power level 10 sec, the Unit remains at this power level, if it is within the regulating range, and it may be shutdown at the load shedding below the regulating range) | | 150 |
| 5.6. Stepped load variation within the regulation range to 20 % of the current power value | | 150 |
| 5.7. Variation of electrical power of the Unit to 5 % Nnom at rate 2 % Nnom per second within the range 50...100 % of the regulation range with the minimal pause between cycles at least 1 minute | | unlimited |
| ***Note.***  Reactor installation power variation rate is limited by the fuel-subjected requirements specified in Table 3.2.1.6.1. | | |
| 6. False EP activation | 150 | |
| 7. Scheduled RCPS tripping | 150 per each pump | |
| 8. Scheduled RCPS startup of the previously idling loop | 230 per each pump (not more than 23 for the service life of FA per each RCPS) | |
| 9. Scheduled HPH tripping and their subsequent startup | 300(not more than 35 within FA lifetime) | |
| 10. PRZ PSD trial | 200 | |
| 11. SG PSD trial | 150 | |
| 12. Trial of ECCS hydraulic accumulators of the first and second stages with water flush to the reactor | 50 | |
| 13. Scheduled cool down up to cold condition at rate up to 30 оС/hr | 70 | |
| 14. Emptying and unsealing of: |  | |
| the reactor equipment | 100 | |
| the other equipment | 60 | |
| 15. Drop of one CPS control rod | 150 | |
| 16. Operation at the reduced parameters at the end of the core lifetime | Operation at reactivity rundown | |
| 17. Carrying out of handling and process operations with fuel under the containment using a refueling machine (loading - unloading) | 15 for the service life of FA | |

Table 3.2.2.1.2 – List of the design modes and number of cycles with disturbance in normal operation conditions

|  |  |
| --- | --- |
| **Mode description** | **Quantity per lifetime** |
| 1. Tripping of different RCPS number | 80 |
| 2. TG SV closing or loss of the external electrical load | 100 |
| 3. Loss of non-emergency AC power supply of the auxiliary station equipment (NPP de-energizing) | 10 |
| 4. Loss of normal feed water flow-rate including complete termination (except for feed water pipeline breakage). EFWP operation | 30 |
| 5. Uncontrolled withdrawal of the most effective CPS CR group from the core (at the nominal power, at the partial power and from the sub-critical state at startup) | 30 (not more than 3 per FA lifetime) |
| 6. Disturbance in boric control system or the operator mistake which causes coolant volume increasing or boron concentration decreasing in the primary circuit | 30(not more than 3 per FA lifetime) |
| 7. Malfunctioning of the control rode (cluster) |  |
| - drop of one control rod; | 10 |
| - withdrawal of one control rod (cluster) from the control group; | 10 |
| - static unbalance by height of one control rod (cluster) in the control group | 10 |
| 8. Unforeseen FA load and operation in wrong position | 5 |
| 9. Unforeseen injection to PRZ from volume and chemistry control system (makeup and blow-down) | 30 |
| 10. False injection to PRZ from RCPS head | 30 |
| 11. The operator mistake at xenon oscillations suppression (CR displacement causing maximally possible deformation of the power-flux field) | 5(not more than 1 per FA lifetime) |
| 12. Malfunctioning of SG power supply system, which brings to feed water flow-rate increasing or to feed water temperature decreasing (including false EFWP activation) | 30 |
| 13. Full inadvertent opening of one feed water control valve | 30 |
| 14.Increasing of steam flow-rate per the turbine (due to steam pressure regulator malfunctioning or failure). Momentary increasing of TG load to 10 % over the nominal one | 100 |

Table 3.2.2.1.2, continued

|  |  |
| --- | --- |
| **Mode description** | **Quantity per lifetime** |
| 15. Steam flow-rate decreasing (due to steam pressure regulator malfunctioning or failure steam pressure regulator malfunctioning or failure). False closing of one MSIV | 10 |
| 16. Unforeseen ECCS activation at the nominal rate, cooling down, cold shut down and during startup | 30 |
| 17. Vacuum-breaking in the condenser | 30 |
| 18. Emergency frequency deviation in network  – from 51,5 to 52,5 Hz – up to 5 min once, but not more than 750 min within the operation life; | not more than 10 cycles per year |
| – from 50,5 to 51,5 Hz – up to 5 min once, but not more than 750 min within the operation life; | not more than 10 cycles per year |
| – from 49,0 to 47,5 Hz – up to 5 min once, but not more than 750 min within the operation life; | not more than 10 cycles per year |
| – from 47,5 to 46,0 Hz – up to 30 sec once, but not more than 750 min within the operation life | not more than 40 cycles per year |

### Tale 3.2.2.1.3 – List of modes and number of cycles for the design basis accidents

|  |  |
| --- | --- |
| **Mode description** | **Quantity per lifetime** |
| 1. Low coolant leakages as the result of the pipeline break (Dnom=<100mm) | 15 (not more than 1 per FA lifetime) |
| 2. Large coolant leakages as the result of the pipeline break (Dnom>100mm including breakage of the main circulation pipeline) | 1 (not more than 1 per FA lifetime) |
| 3. CPS control rod ejection at the drive housing breakage | 5 (not more than 1 per FA lifetime) |
| 4. SG PSD unfitting | 15 (not more than 1 per FA lifetime) |
| 5. PRZ PSD unfitting | 3 (not more than 1 per FA lifetime) |

Table 3.2.2.1.3, continued

|  |  |
| --- | --- |
| **Mode description** | **Quantity per lifetime** |
| 6. Unfitting of the steam relief device valves (one per each of four BRU-A units and one per each of 6 BRU-K units) | 8 (not more than 1 per FA lifetime) |
| 7. Momentary shaft sticking or breakage of one RCPS among different number of running ones | 4 (not more than 1 per FA lifetime) |
| 8. Spectrum of the steam-line breakages inside and outside the protective housing (including the case of SG gathering header breakage), except for SG pipe breakage. | 4 (not more than 1 per FA lifetime) |
| 9. Breakage of SG feed water pipeline | 4 (not more than 1 per FA lifetime) |
| 10. Breakage of the main steam header | 1 (not more than 1 per FA lifetime) |
| 11. Break away of primary circuit SG header cover, one per each steam-generator | 4 (not more than 1 per FA lifetime) |
| 12. Fuel handling accidents during TPE (including FA drop to the fuel pool during refueling) | 1 (not more than 1 per FA lifetime) |
| 13. The operator’s mistakes at the loop connection (RCPS activation without preliminary power reducing), one per each loop | 4 (not more than 1 per FA lifetime) |
| 14. Compensatory leak of the fuel pool | 1 (not more than 1 per FA lifetime) |
| 15. Breakage of SG heat exchanging tube followed by cool down at the rate 60 оС/hr | 30 (not more than 1 per FA lifetime) |
| 16. Leakage from the primary circuit to the secondary one within SG (Dу=<100mm), except for SG heat-exchanging pipe breakage | 4 (not more than 1 per FA lifetime) |
| 17. Breakage of I&C line or other lines from the reactor coolant pressure boundary, which pass through the emergency housing | 30 (not more than 1 per FA lifetime) |
| 18. Leakage or damaging of the systems containing gaseous radioactive wastes | 10 (not more than 1 per FA lifetime) |

Table 3.2.2.1.3, continued

|  |
| --- |
| ***Notes***:  1 Modes as per items 4, 5 are considered as inadvertent opening followed by unfitting.  2 In modes as per 8, 9 the spectrum of the pipeline diameters is considered.  3 Modes listed in Table 3.2.2.1.3 are considered with overlapping of NPP de-energizing. De-energizing is accepted as in the most adverse moment of an accident.  4 Nnom – maximal net power reached in the process of NPP operation in normal modes.  5 The specified list of modes is intended to justify RP equipment strength. The total number of modes with disturbance of normal operational conditions counting on strength is accepted as not more than 300, the emergency modes are not more than 30. At the same time, for each unit it is required to consider the most adverse modes from the strength viewpoint. |

#### 3.2.2.2 Permissible number of cycles and loading conditions, as well as the lifetime of auxiliary system pipelines directly joining the primary circuit pipelines up to the second isolation valves counting from the place of in-cut to the primary circuit, damage of which may be the initial emergency event, corresponds to the cycles, loading conditions and the lifetime of the relevant primary circuit equipment.

#### 3.2.2.3 Number of FA loading cycles within the lifetime shall not exceed the values specified in Tables 3.2.1.6.1, 3.2.2.1.1, 3.2.2.1.2, 3.2.2.1.3 and those specified in the catalogue description «Complex of the integral part of the WWER-1000 (type V-446) core 0401.16.00.000 DKO.

Limitations, relating to the core, of the number of cycles of each mode, specified in Table 3.2.2.1.2, is not applied to cases of concurrent occurrence of two and more of these modes. In case two and more modes of this section occur concurrently, it may require to carry out an inspection of the core. While implementing mode, specified in Table 3.2.2.1.3, it is necessary to inspect the core to define the suitability of fuel assemblies, CPS control rods and BAR bundles to their further operation. Operability of fuel assemblies, CPS control rods and BAR bundles shall be defined by an experienced group of representatives of the Principal (Consumer), Supplier and Manufacturer of the core component parts.

#### 3.2.2.4 At the beginning of commissioning activities, the continuous acquisition and storage of the data on recording the passed normal operation modes, disturbances in normal operation and the design basis accidents shall be provided in order to accumulate the statistics.

To control the remaining lifetime of RP elements (units), the design envisages the relevant CAS subsystem within MCDS, including the software of monitoring the residual cyclic resource of RP main equipment and performs functions of monitoring the residual cyclic resource of the following RP equipment elements:

* reactor vessel;
* pressurizer;
* steam generators;
* main coolant pipelines;
* pressurizing system pipelines.

#### 3.2.2.5 The following limits are imposed to the primary circuit coolant temperature and the reactor plant elements during hydraulic testing by pressure 24,5 MPa (250 kgf/cm2) and tests for tightness by pressure 17,6 MPa (180 kgf/cm2) within the lifetime:

|  |
| --- |
| 1) Minimum temperature of primary circuit coolant, when (taking into account coolant and equipment metal cooling-down during hydraulic tests) increase of pressure is allowed in the primary circuit to the hydraulic tests pressure depending on the time of RP operation, is given in table 3.2.2.5.1. |

Table 3.2.2.5.1 - Dependability of coolant minimum temperature before pressure increase to the pressure of the primary circuit hydraulic tests on RP operation duration

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| RP operation duration, years | 0 | 1 | 4 | 7 | 8 | 12 | 16 | 20 | 24 | 28 | 30 | 40 |
| Minimal temperature, °С | 100 | 130 | 130 | 130 | 107 | 113 | 118 | 122 | 125 | 129 | 130 | 137 |

2) Minimum temperatures of RP equipment external surfaces during hydraulic tests are given in table 3.2.2.5.2.

Table 3.2.2.5.2 - Minimum temperatures of RP equipment external surfaces during hydraulic tests

|  |  |
| --- | --- |
| **Name of equipment, pipelines** | **Minimum temperature of external surface, °С** |
| 1 SG coolant header | 70 |
| 2 Pressurizer body | 75 |
| 3 RCPS primary circuit body and elements | 50 |
| 4 RCP | 50 |
| 5 Pressurizer system connecting pipeline | 45 |
| 6 ECCS passive part pipelines within the boundary of the primary circuit | 40 |
| 7 Emergency gas removal system pipelines within the boundary of the primary circuit | 20 |
| 8 SG vessel | 80 |
| 9 ECCS tank vessel | 30 |
| 10 ECCS pipelines from the tank to the first shutoff gate valve | 40 |
| 11 Bubbler tank vessel | 20 |
| ***Note*** – Minimum temperature of the surfaces of RCPS primary circuit vessel and elements, SG coolant header and bubbler tank vessel is identified by the coolant temperature. | |

3) Maximum temperature of the coolant during hydraulic tests is not more than 140 °С.

4) Hydraulic tests parameters of RP equipment not included into the primary circuit are given in table 3.2.2.5.3.

Table 3.2.2.5.3 - Hydraulic tests parameters

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Description of system, part of system,**  **equipment or pipelines** | **Oper. pressure,**  **MPa** | **Hydraulic tests pressure, (permissible limits of fluctuation) MPa** | **Inspection pressure,**  **(permissible limits of fluctuation),**  **MPa** | **Hydraulic tests temeprature, °С** |
| 1 Dead-end sections of ECCS pipelines | 17,66 | 24,5  (24,5-25,0) | 19,62  (19,62-20,6) | 40-120 |
| 2 SG for secondary circuit | 7,84 | 10,79  ( 10,79-11,3) | 8,62  (8,62-9,07) | 90-120 |
| 3 ECCS tank | 6,37 | 8,33  (8,1-8,5) | 6,64  (6,64-7,0) | 40-60 |
| 4 ECCS pipeline section from the tank to the first shutoff gate valve | 6,37 | 8,33  (8,1-8,5) | 6,64  (6,64-7,0) | 40-60 |
| 5 Bubbler tank vessel with the discharge pipeline section to pressurizer PORV | \*) | 0,98  (0,96-1,09) | 0,78  (0,77-0,87) | 20-60 |
| \*) Operating pressure for bubbler tank vessel is 0,69 MPa, for discharge pipeline section from the bubbler tank to pressurizer PORV is 11,3 MPa. | | | | |

Table 3.2.2.5.4 - Dependability of the reactor vessel surface temperature on the operation period when hydraulic tests and leaktigtness tests

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Duration of RP operation, years | 0 | 1 | 4 | 7 | 8 | 12 | 16 | 20 | 24 | 28 | 32 | 36 | 40 |
| Minimal temperature at hydraulic tests for strength  (Р=24,5 MPa), °С | 75 | 105 | 105 | 105 | 82 | 88 | 93 | 97 | 100 | 104 | 106 | 109 | 112 |
| Minimal temperature at hydraulic tests for tightness (Р=17,7 MPa), °С | 48 | 78 | 78 | 78 | 62 | 68 | 73 | 77 | 80 | 83 | 86 | 89 | 91 |

#### 3.2.2.6 Within the operation period at the heated-up SG, not more than 240 blow-downs of each pulse lines of the single-chamber surge tanks are allowed with water at temperature (164±4) °С.

#### Number of drastic feed water temperature variation cycles from 220 °С to 160 °С is not more than 400 within the whole lifetime.

#### In case of the emergency cool down, water with temperature from 5 °С to 40 °С may be supplied by an individual main pipe in SG within the whole cool down period. The number of cycles is 80 per each steam-generator within the whole service life.

3.2.2.7 Earthquakeeffects(according to MSK-64 scale):

Safe shutdown event (SSE), points: 8 (7.6)

- horizontal acceleration, g 0.40

- vertical acceleration, g 0.22

Design basis earthquake (DBE), points: 6 (6.2)

- horizontal acceleration, g 0.20

-vertical acceleration, g 0.13

#### Duration of RCPS operation in the design basis earthquake conditions is not more than one minute, the number of the design basis earthquakes for the whole lifetime of the bearings and shaft sealing is not more than two minutes. After SSE and after design basis earthquake the inspection of the pump is required.

#### 3.2.3 Parameters characterizing serviceable condition of the systems important to safety

#### Parameters characterizing serviceable condition of the systems important to safety and controlled in the process of normal operation are specified in Appendix B.

#### 3.2.4 Operational limits as per radiation parameters

3.2.4.1 Reference levels (RL) of radioactive gases and aerosols releases to the atmosphere for NPP per month are brought in the following table 3.2.4.1.1.

Table 3.2.4.1.1

|  |  |
| --- | --- |
| Radionuclides | RL, Bq/month |
| IRG | 5,7×1013 |
| Iodine-131 | 1,5×109 |
| 60Co | 6,2×108 |
| 134Cs | 7,5×107 |
| 137Cs | 1,7×108 |
| Note: in individual months a release of radionuclides, which exceeds RL 3 times, is allowed on condition that the annual PR will not be exceeded. | |

#### 3.2.4.2 The permissible discharge with radioactive drains within the defined time period in the process of operation for any reference radioactive nuclide or sum of the radioactive nuclides shall not exceed the value equal to a portion of the maximally permissible annual discharge value, proportional to the time passed from the beginning of the calendar year. Operational limit shall be calculated by formula:

PDop = PDannual × t/ 365, Ci

where PDop – operational limit for the permissible discharge;

PDannual – annual permissible discharge (safety operation limit);

t – number of days within the time period from the beginning of the calendar year up to the moment of sampling.

During calculation of the operational limits, PDannual values shall be taken as per item 3.3.4.2 and Table 3.3.4.2.1.

If there are several radioactive nuclides in the drains, the sum of these individual radioactive nuclides activity ratios to their operational limit PDop shall not exceed one.

At the irregular discharge within a year it is allowed to exceed the operational limits during certain periods provided this exceeding is compensated during further periods of the calendar year.

#### 3.2.4.3 The operational limits of discharge for individual radioactive nuclides, calculated as per formula in item 3.2.4.2, may vary within the large range, but their specific concentration in liquid wastes shall not exceed the values listed in Table 3.2.4.3.1. The specified values are the permissible concentration for drinking water (PL Apop.) as per P-2 NRB-96.

Table 3.2.4.3.1 – Permissible concentration of radionuclides in liquid discharges outside the NPP

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Nuclide | Cr-51 | Mn-54 | Co-58 | Fe-59 | Co-60 | Sr-89 | Sr-90 | Zr-95 | Nb-95 | Mo-99 |
| Permissible concentration, Bq/kg | 3,3×104 | 1,8×103 | 1,7×103 | 6,9×102 | 3,7×102 | 4,8×102 | 4,5×101 | 1,3×103 | 2,1×103 | 2,1×103 |
| Nuclide | Ru-103 | Ru-106 | I-131 | Te-132 | Cs-134 | Cs-137 | Ba-140 | La-140 | Ce-141 | Ce-144 |
| Permissible concentration, Bq/kg | 1,7×103 | 1,8×102 | 5,7×101 | 3,4×102 | 6,6×101 | 9,6×101 | 4,8×102 | 6,3×102 | 1,8×103 | 2,4×102 |

#### 3.2.4.4 The permissible value of the total specific activity of iodine 131-135 radioactive nuclides in the primary circuit coolant is not more than 3,7×107 Bq/kg (1×10-3 Cu/kg). The specified value corresponds to the operational limit of RP operation by number of leaking FE equal to 0,2% of gas-leaking FE and 0,02% of FE having direct contact of fuel with coolant (in recalculation to the design flow-rate of the primary circuit coolant blow-down to filters ТС – 30 t/hr and degassing flow-rate in ТА system - 5 t/hr).

#### 3.2.4.5 The permissible value of the primary circuit coolant leakage by individual steam-generators is 4 kg/h.

#### 3.2.4.6 The permissible value of the actually measured activity of isotope 131I in blow-down water from «salt» chamber of each SG is 370 Bq/kg.

**3.3 Safe operational limits**

3.3.1 The value of the total specific activity of iodine 131-135 radioactive nuclides in the primary circuit coolant shall not be over 1,85×108 Bq/kg (5×10-3 Cu/kg). The specified value corresponds to the safety operation limit by number of leaking FE, equal to 1 % of gas-leaking FE and 0,1 % of FE having direct contact of fuel with coolant (in recalculation to the design flow-rate of the primary circuit coolant blow-down to filters ТС – 30 t/hr and degassing flow-rate in ТА system - 5 t/hr).

3.3.2 The safety operation limit of the value of iodine-131 radionuclide specific activity in blow-down water of each SG is not more than 740 Bq/kg (2×10-8 Cu/kg).

3.3.3 The safety operation limit of the value of leakage from primary circuit to the secondary one by individual SG is not more than 5 kg/hour.

3.3.4 Safe operational limits by radiation parameters.

3.3.4.1 Annual permissible levels of releases of radioactive gases and aerosols into the atmosphere for the NPP brought in table 3.3.4.1.1.

### Table 3.3.4.1.1

|  |  |
| --- | --- |
| Radionuclides | Annual release, Bq/year |
| IRG | 6,9 ×1014 |
| I-131 | 1,8×1010 |
| 60Co | 7,4×109 |
| 134Cs | 9,0×108 |
| 137Cs | 2,0×109 |

3.3.4.2 Permissible discharge of radionuclides in the environment with liquid drains of the NPP (outside the NPP) per one calendar year shall not exceed the values brought in table 3.3.4.2.1.

Table 3.3.4.2.1

|  |  |
| --- | --- |
| Permissible discharge (PD), Bq/year | |
| Tritium | 4,4×1013 |
| Radionuclides\* | 2,1×1010 |
| ***Note***: Radionuclides\* - total activity of the following radionuclides in liquid drains of the NPP: Sr-89, Sr-90, Mo-99, Ru-103, Ru-106, I-131, Te-132, Cs-134, Cs-137, Ba-140, La-140, Ce-141, Ce-144, Zr-95, Nb-95, Fe-59, Co-58, Cr-51, Mn-54, Co-60 | |

3.3.4.3 Values of the personnel exposure dose limits shall not exceed the values specified in Table 3.3.4.3.1.

### Table 3.3.4.3.1 – the main exposure dose limits for different categories of the personnel

|  |  |
| --- | --- |
| Personnel category | Individual effective dose |
| Group A | 20 mSv (2 Rem) per year in average for any successive 5 years, but not more than 50 mSv (5 Rem) per year |
| Group B | Radiation dose shall not exceed 1/4 of values for the personnel of group А |

#### 3.3.5 Maximal design pressure (absolute) under the confinement during the design basis accident is 0,46 MPa (4,7 kgf/cm2).

#### 3.3.6 The safe operation limits by the process parameters of the primary and secondary circuits are specified in Table 3.3.6.1.

Table 3.3.6.1 Safe operational limits by process parameters of the primary and secondary circuits

|  |  |
| --- | --- |
| **Parameter** | **Parameter value** |
| Period of thermal neutron flux variation | 10 sec |
| Maximum primary circuit pressure | 180/190 kgf/cm2 \*\* |
| Minimal primary circuit pressure at power not less than 75 % of Nnom, at power less than 75 % of Nnom | 148/Р(TsI+10°С) kgf/cm2  140/Р(TsI+10°С) kgf/cm2 |
| Maximal pressure in one of SG by the secondary circuit | 80/86 kgf/cm2 \*\* |
| Minimal pressure in one of SG by the secondary circuit | 52/45 kgf/cm2 \* |
| Maximal temperature in hot leg of the circulation loop | (Тnom+8)/(TsI-10)°С |
| Minimal level in one PG after protection activation «Нnom-900 – EFWP actuation moment» | (Нnom-900)/(Нnom-1100)mm\* |
| Minimal level in PRZ | 4600/4200 mm |
| Maximal temperature at the core top after cool down in the mode of residual heat removal (including the mode of maintenance cool down) | 80 °С |
| Notes: 1. In numerator, the value of the parameter is specified which is before the reactor emergency protection activation, in denominator – after the reactor emergency protection activation.  2. \*) The parameter value may be reduced in case of taking a decision on the Unit changeover to the mode in which reaching the energy level of power (e.g., cool-down) is not envisaged.  3. \*\*) Except for mode of hydraulic testing. | |

# 4 HEAT-UP AND STARTUP OF THE UNIT

**4.1 Safe operational conditions at the unit heat-up and startup**

#### This section contains the requirements to the Unit systems, terms on their quantity and condition required for safety assurance at the stages of the Unit heat-up and startup.

#### The requirements to the equipment and systems parameters are listed in Appendix B.

#### In case of revealing any deviations of the equipment parameters from the specified requirements, it is not allowed to changeover the Unit from “cold” condition to “hot” condition and from “hot” condition to MCL.

#### In the process of the Unit heat-up and startup, the equipment and systems status and parameters of which are defined by safety operation conditions of the Unit shall be successively checked for serviceability and brought to the ready state. The instructions on the scope of testing and checks to be performed at the stages of the Unit heat-up and startup are specified in section 10.2.

#### At the stages of the Unit preparation for startup, prior to commencement of check for serviceability and bringing the equipment and systems to the ready state the heads of subdivisions – owners of the equipment shall make the records in the “Log-book of the technical directives” at the SSU workplace on readiness of the equipment for checking, on changes in the equipment circuits and structure, the instructions are given to the operative personnel on the sequence of activities based on the introduced changes, a permit is given to perform checks and put the equipment to operation (to standby). The operational documentation available at the workplaces of the operative personnel shall be corrected in compliance with these changes prior to commencement of the Unit heating-up up to the nominal parameters.

**4.1.1 Safety Unit operation conditions in “cold” mode**

#### 4.1.1.1 Condition of the reactor plant systems and equipment:

1) parameters characterizing RP “cold” condition are listed in item 2.2.2.4

2) The operations on the reactor refueling are completed, correspondence of its core loading to the approved map of the regular reactor refueling is checked, height-wise layout of FA caps is checked, unavailability of the core components damages and unavailability of extraneous items in the inter-vessel pit and at the FA caps is checked.

PTU is mounted on the assembled core. PTU motion speed have been measured at UU installation and the reactor main joint sealing.

3) Coolant level in the primary circuit is not lower the upper constituent of the reactor cold nozzles.

4) The main reactor joint and the primary circuit equipment are assembled and sealed.

5) All CPS drive bars are coupled with their CPS AR. Monitoring of forces for CPS CR displacement from UU using the special tool.

6) The electrical joints are connected to CPS drives.

7) Electrical connection is performed using the plugs of ICDS (NFTMC, NFTLMC) with SHW-3 devices (ICIS) and LIE.

8) Neutron flux in the reactor core is controlled by NFME.

9) Preventive units and the cross-arm are mounted to the UU.

10) At least two PRZ PSD are in ready state.

11) The following is mounted:

- hydroseal of the spent fuel fuel pool No. 1 between the spent fuel pool and the reactor internals inspection pool;

- hydroseal of the spent fuel pool No. 2 (protective) between the spent fuel pool and the reactor internals inspection pool;

- hydroseal of the spent fuel pool container section between the spent fuel pool and the container section.

12) FP is filled with boric acid solution with concentration 16-20 g/dm3 up to elevation 21,0 m as well as if there are no spent fuel in it. If it is necessary to correct SFP WC, the level decrease in SFP is allowed to the elevation not lower than +19.0 m for the time required to correct WC in SFP, but not more than 24 hours, during SFP cooling system TH18(28,38,48) operating in the standard mode and continuous temperature control of BAS in SFP, which does not exceed 50 ºС.

The reactor internals inspection well is completely emptied. The following are drained also: container section and upper cavity of the reactor. Valves at the container section drainage pipelines TH70S012,013, reactor internals inspection well TH70S007,008, upper reactor cavity ТН70S018,019 and TH70S014 are open. Electric circuits of valves are disassembled; the flywheels valves are locked.

13) The primary circuit overpressure protection is activated, it trips make-up pumps and PRZ TEH at the primary circuit pressure increasing over 3,4 MPa (35 kgf/cm2) in case if the primary circuit temperature is lower than 100 °С. The PRZ TEH circuits are disassembled.

14) Pressure in all first stage ECCS HA is not more than 3,4 MPa (35 kgf/cm2).

It is allowed to increase pressure over 3,4 MPa (35 kgf/cm2) to check ECCS HA SV provided that all fast-acing gate valves YT11,12,13,14S001,002 on the lines connecting the tanks to the primary circuit are closed, the electrical circuits are disassembled, the flywheels are locked.

All ECCS HA of the second stage (TH16,17,26,27,36,37,46,47B001) are under 2,5 MPa pressure of nitrogen blanket and filled up to the nominal level 10130±100 mm with boric acid solution at concentration not less than 16 g/kg, gate valves TH16,17,26,27,36,37,46,47S001,002 at the connection lines between the hydraulic accumulators and the primary circuit are closed, the electric circuits are disassembled, flywheels are locked.

15) The emergency primary circuit gas removal system (YR) valves are ready for operation, as well as the valves on the drainages of U-type MCP sections.

16) Serviceability of MSIV piping valves is checked.

17) The primary circuit equipment joints tightness control system is in operation. There is no pressure in inter-sealing space of the joints.

18) Status of the hydraulic snubbers is checked. All hydraulic snubbers shall be in serviceable condition.

19) Blow-down of the primary and secondary circuits I&C pulse lines has been performed.

20) The electrical circuits of pumps ТH15,25,35,45D001, ТW10,20,30,40D001, ТА31,32,33D001 are disassembled to exclude primary circuit overpressurization by pressure higher than 35 kgf/cm2 at their accidental or automatic actuation.

21) measures are taken to avoid coolant ingress to the primary circuit at boric acid concentration less than 16 g/dm3.

#### 4.1.1.2 Status of the main schematic diagram and the Unit house-load power supply:

1) The main schematic diagram provides for full power generation by the operating NPP Unit to the grid and power supply of the Unit house-load by feeding 10 kV sections of normal operation - BA, BB, BS, BD, BE, BF from AT or SAT.

2) 0,66 kV and 0,4 kV sections are fed by operating or standby bushings.

3) It is allowed to remove voltage from one 10 kV section and one 0,66 kV or 0,4 kV section of normal operation provided that at least three EPSS channels are in operation fed from operating bushings from normal operation sources, i.e. power supply to the safety systems consumers of the 1st and 2nd group is provided by at least three channels.

4) The direct current boards are fed by the regular circuits, the storage batteries are completely charged and are in the flotage mode. It is allowed to withdraw from operation DCB and SB of one of four EPSS channels as well as DCB of normal operation and I&C.

5) Power supply of MCR and ECR panels and desks is provided from the power supply system of normal operation.

#### 4.1.1.3 The emergency power supply system of the Unit meets the following requirements:

1) At least three EPSS channels are in operation. Power is supplied to the consumers of the 1st and 2nd group safety systems via the operating bushings of 10 kV sections from normal operation sources and further by the regular circuit to 0,66 kV and 0,4 kV sections and DCB.

2) Diesel-generators corresponding to the serviceable EPSS channels are checked and ready for operation.

3) Storage batteries corresponding to the serviceable EPSS channels are charged and in flotage mode.

4) UPS corresponding to the serviceable EPSS channels are connected by the regular circuit. UPS rectifiers run load of the direct current boards and flotage of the storage batteries.

5) From the moment of energizing the equipment, its protection and I&C system are put into the design position. Fire alarm and automatic fire protection systems are alerted; supporting systems are put into operation (ventilation, conditioning lighting systems). The premises are closed to prevent access of the unauthorized persons.

#### 4.1.1.4 The following SS systems corresponding to the serviceable EPSS channels are in operation:

1) Three channels of the primary circuit emergency and scheduled cool down and fuel pool chilling system (TH10,20,30,40) and three channels of the containment spray system (TJ10,20,30,40).

The electric circuits of emergency boron injection group pumps TH15,25,35,45D001, extra borating pumps TW10,20,30,40D001 are disassembled to avoid accidental pressurization of the primary circuit.

The electric circuits of valves TJ11,21,31,41S001 at the sprinklers supplying lines are disassembled to avoid false actuation.

One channel of TH system is functioning for the reactor core residual heat removal.

The interlocks are activated to protect the primary circuit equipment against over-pressurization at low temperature.

It is allowed to terminate the forced circulation via the reactor core for the time of the primary circuit testing at pressure not more than 3,4 MPa (35 kgf/cm2), the tests for checking the effectiveness of group TH10,20,30,40 of the emergency and scheduled cool down system with supply to the primary circuit, but not more than 2,5 hours.

2) Three channels of the service cooling water system VE for secured closed cooling water systems TF and VJ corresponding to the serviceable channels of TH system.

1. Three channels of the intermediate circuit for nuclear component cooling system TF important consumers cooling water system VJ corresponding to the serviceable channels of TH system.
2. Not less than one compressor plants TM10D001(002) are on duty to maintain the design pressure in the receivers of the instrument air system. The instrument air supply is provided to control the air actuators of valves.
3. The automated fire protection system of safety system train is completely in the standby mode.
4. Ventilation systems providing for normal functioning of SS equipment being in operation or standby, namely:

* six recirculation cooling systems for intermediate circuit pump compartment and emergency boron injection in ZB building (TL08D014, D017, D018, D021, D023 D024, D025, D026) are in serviceable condition;
* three recirculation plants for the primary circuit cool down compartments in ZB building (TL08D015, TL08D016, TL08D019, TL08D020) are in serviceable condition;
* three recirculation cooling plants for the heat-exchangers compartments of the important consumers cooling system (TL08D039…TL08D042) are in serviceable condition;
* six recirculation cooling plants for the cable compartments in ZB building (TL08D002÷TL08D009) are in serviceable condition;
* three recirculation cooling plants for the boric acid tanks compartment in ZB building (TL08D010÷TL08D013) are in serviceable condition;
* three plants of the emergency exhaust system for creating rarefication in the annulus of ZB building (TL10D001÷TL10D004) are in serviceable condition;
* six recirculation cooling plants for the safety channels compartments of the steam chambers (UV13D001÷ UV13D008) are in serviceable condition;
* one plant of the MCR habitability system (UV21D008, UV22D008) is in serviceable condition;
* three plants of the air conditioning system in MCR premises (UV22D007; UV23D006, UV23D007; UV24D006, UV24D007) are in serviceable condition;
* three plants of the MCR cable floor ventilation system (UV21D005, UV23D005, UV24D005) are in serviceable condition;
* one plant of the ECR habitability system (UV31D008, UV32D008) is in serviceable condition;
* three plants of the air conditioning system in ECR premises (UV31D006, UV31D007; UV32D006, UV32D007; UV33D006, UV33D007; UV34D006, UV34D007) are in serviceable condition;
* three recirculation cooling plants for the important consumers pumps compartments in ZМ building (UV11D010÷ UV11D013) are in serviceable condition;

- three plants of cold-air supply system for the ventilation units in the safety channels compartments (UF40, UF50, UF60, UF70) are in serviceable condition.

7) CMS providing for monitoring, control and protection of SS functional mechanisms are activated.

#### 4.1.1.5 Premises where the equipment of serviceable SS channels is located are closed against access of the unauthorized persons.

#### 4.1.1.6 At least two channels of the spent fuel pool chilling system with pumps TH18,28,38,48D001 are ready for operation. One channel of the spent fuel pool chilling group TH18,28,38,48 is functioning for FP chilling. It is allowed to terminate FP cool down for the time of making switchovers at the cooling system but not more than for three hours at BAS temperature in FP not more than 70 °С.

#### 4.1.1.7 The nuclear equipment drain system in reactor compartment (TY-1) and nuclear equipment drain system in ZC (TY-2) is ready for operation. At least one pump TY31(32)D001 of TY-1 system and one pump TY21(22)D001 of TY-2 system are ready for operation.

#### 4.1.1.8 The primary circuit make-up and blow down system is ready for operation. Make-up deaerator is filled with boron-containing water at concentration not less than in the primary circuit. At least two make-up pump TA31(32,33)D001 is ready for operation.

#### 4.1.1.9 At running make-up pumps, the coolant storage and treatment system TD shall be in operation as well. One pump TD71(72,73)D001 is in serviceable condition. An unconfined space 240 m3 is prepared in the tanks to intake the discharged primary circuit waters.

#### 4.1.1.10 The measures are taken on non-ingress of distillate to the primary circuit coolant as per the requirements of the "Operating instruction on the reactor plant".

#### 4.1.1.11 Borated water storage system TH is in ready-for-operation state:

#### Each of the borated water storage tanks TH10,20,30,40B001, TH10,20,30,40B002 has 197,5 m3 of the boric acid solution at concentration 16-20 g/dm3 in stock.

#### The boric acid storage tanks (TB20B001,002) have 60 m3 of the boric acid solution at concentration 39,5-44,5 g/dm3 in stock.

#### One of the pumps TB21,22D001 is in serviceable condition.

#### 4.1.1.12 The pumps of the radioactive drain subsystems TZ11,12,13,14D001, TZ21,22,23,24,25,26,27,28,29D001, TZ31,32,33,34,35,36,37,38,39,40D001 are serviceable, the possibility of drains intake for refinement is provided.

#### 4.1.1.13 At least one SGT channel is in operation. The blow-offs from the equipment (the relief tank, controlled leakage heat-exchanger, the controlled leakage tank, coolant storage tanks) are sent to process blow-off hydrogen burn-up system TS10 and to gas treatment system TS20.

#### 4.1.1.14 Low pressure nitrogen system TP is in operation.

#### 4.1.1.15 NFME is in operation. The reactor power excursion and neutron power control is provided by at least three measurement channels. Indications of all functional flux density control channels are recorded in TLS-U. The power excursion audible warning devices are turned on. Period protection setpoints are set to position EP: 20 sec. PP- 40 sec, and power setpoints are not higher than 10-3 % Nnom.

#### 4.1.1.16 ARSMS system is in operation. The control for radiation situation in the Unit premises and activity of exhausts via the vent stack is provided.

#### 4.1.1.17 The regular paging and phone operative communication with the workplaces and premises is in operation.

#### 4.1.1.18 The regular and emergency lighting is in operation.

#### 4.1.1.19 Isotope 10 concentration in the boric solutions of the safety system tanks, ECCS hydraulic accumulators shall be no less than 19,5 % of the total concentration of all boron isotopes. Periodicity of control - 1 time every year before starting up of the power Unit after PPM.

4.1.1.20 Water chemistry of the primary and secondary circuits corresponds to water chemistry requirements specified in Appendix F.

**4.1.2 Safety operation conditions in the process of the reactor plant heat-up**

#### 4.1.2.1 During heat-up, the reactor plant equipment shall meet the following requirements:

1) At the primary circuit pressure higher than 1,8 MPa (18,4 kgf/cm2), the reliable separation of the high pressure and low pressure pipeline sections is provided, the relevant records are made in the operative log-book of SSRC, SSU.

The electric circuit of the interfacing valves power supply is disassembled except for the system of emergency gas removal from the primary circuit (YR) and air removal from RCPS off-line circuits.

1. At least one PSD PRZ in ready state.

It is allowed to pre-deform PRZ PSD PPV for the time of the primary circuit hydraulic tests for strength and tightness.

3) There is nitrogen blanket or steam cushion in PRZ.

PRZ level corresponds to the primary circuit coolant temperature. For the time of the primary circuit hydraulic tests it is allowed to fill PRZ up to the top.

PRZ electrical heaters are in serviceable condition.

4) The RT is filled up to the nominal level (1700 mm). The integrity of its rupture disks is checked. Water temperature is within the established limits (20÷60)°С. The level maintaining and RT blow-off systems are ready for operation.

5) To provide for the reactor core residual energy-release removal, the following is in operation:

а) TH system, if the primary circuit pressure is less than 1,8 MPa (18,4 kgf/cm2) and the primary circuit temperature is less than 150 °С;

b) at least one RCPS, if TH system is not in operation and there is the nitrogen blanket in PRZ.

At the primary circuit temperature less than 200 °С, operation of more than three RCPS is forbidden.

It is allowed to trip RCPS for the time of hydraulic testing for the primary circuit tightness, as well as for the time of TH system connection to the primary circuit.

At the same time, control availability of at least 15 °С margin up to boiling up at the FA outlet.

6) The level in each SG is (3700÷3800) mm.

It is allowed to decrease level in SG up to the nominal one provided that water is boiling in SG.

It is allowed to fill in the steam-generators and steam-lines up to the turbine stop valves for the time of the secondary circuit hydraulic testing.

7) SG PSD are ready for operation. It is allowed to disable SG SV PPV for the time of hydraulic testing and the secondary circuit testing for tightness.

8) At the primary circuit pressure more than 6,4 MPa (65 kgf/cm2), the first and second stage ECCS HA are connected to the primary circuit (except for the primary circuit hydraulic test mode). Medium parameters in ECCS HA are nominal.

9) The primary circuit water chemistry corresponds to the requirements listed in Appendix F.

10) Difference between the metal temperature of the PRZ vessel top and bottom parts is 85 °С, SG - 40 °С.

11) Difference between feed water temperature supplied to the steam-generator and the vessel temperature measured at the outer surface and at the steam-generator vessel bottom point shall not exceed 120 °С.

12) In the process of heating-up modes, the primary circuit cool down and operation at power, the upper unit equipment cooling system TL13 is in operation, as well as the reactor cavity space TL03.

13) MCDS diagnostics systems VMS are ready.

14) measures are taken to avoid coolant ingress to the primary circuit at boric acid concentration less than 16 g/dm3.

#### 4.1.2.2 To reach the primary circuit temperature as 150 °С, the containment integrity is provided:

1) The process primary circuit premises are checked for absence of people, burnable and explosive objects. Upon completion of check these premises shall be closed and sealed. The records shall be made in the operative log-books of SSRC, SSU.

2) The material lock is closed and sealed.

3) All doors of personnel locks to the containment premises and annulus are closed and sealed. The interlocks for the locks opening (closing) are activated. The procedure of access to the containment premises is defined by the “Instruction on the containment access procedure» at the power plant.

4) All control systems of the locks are serviceable, as well as the signaling on the lock door positions at MCR.

5) The rarefication degree under containment shall be within 150-275 pa. The design interlocks shall be activated to maintain rarefication under the containment.

6) The rarefication degree in the annulus shall be within (100÷400) Pa.

4.1.2.3 In heat-up process, the primary circuit pressure shall not exceed the values specified in Appendix H.

#### 4.1.2.4 By measure of heat-up, the equipment and systems, status and characteristics of which define the Unit safety operation conditions in «hot» condition shall be sequentially checked for serviceability and brought to the ready state.

4.1.2.5 Water chemistry of the primary and secondary circuits corresponds to water chemistry requirements specified in Appendix F.

4.1.2.6 Primary circuit coolant temperature change rate at heat-up is not more than 20 °С/h.

**4.1.3 Safety operation conditions of the Unit in the "hot" condition**

#### The parameters characterizing the Unit in the «hot» standby are specified in item 2.2.2.3.

#### At transition to hot standby from cold condition, boric acid concentration in primary circuit coolant shall be not less than 16 g/dm3.

#### The Unit state in «hot» standby shall meet the following requirements:

#### 4.1.3.1 The reactor plant equipment condition.

#### 1) The pressurizing system is in operation:

#### а) PRZ is in steam mode. PRZ level is (5100±150) mm. The PRZ level maintaining control device is set to the automatic mode.

#### b) PRZ electric heaters are in operation.

#### c) The primary circuit pressure regulator is set to the automatic mode and the interlocks on injection valves YP11,12,13S002, YP11,12S001, YP13S003 are activated. PRZ PSD are ready for trial run, adjustment and putting into operation.

#### For the period of PRZ PSD trial run, it is allowed to trip two other PRZ PSD by the actual primary circuit pressure increasing.

#### d) PRZ system valves position shall correspond to the following state:

#### - YP11,12,13S002 is at the automatic control;

#### - valves YP11,12S001, YP13S003 are in open position;

#### - YP13S004 is in closed position.

#### 2) At least two RCPS are in operation, the other RCPS are ready for operation. The intermediate circuit cooling water and sealing water is supplied to them.

#### It is allowed to trip RCPS, terminate forced circulation via the reactor core for the time of PRZ PSD serviceability check by actual pressure increasing. At the same time, control availability of at least 15 °С margin up to the boiling up at the FA outlet

#### 3) level in each SG is nominal (2400±50 mm). The startup-and shutdown regulators maintaining SG level are set to the automatic mode.

#### The SG blow-down system is activated.

#### SG PSD activation settings are ready for checking.

#### 4) ECCS passive part is checked for serviceability and readiness for operation.

#### The first stage ECCS hydraulic accumulators:

#### а) The check is performed with ECCS HA flushing to the reactor. ECCS HA are connected to the primary circuit. All fast-acting gate valves YT11,12,13,14S001,002 are opened. The valves on the check valves bypass are closed.

#### b) ECCS HA parameters are nominal: the level is (6500±100) mm, pressure is 5,88±0,10,3 MPa (60±0,982,94 kgf/cm2). Solution quality corresponds to the normative indices specified in Appendix F.

#### c) ECCS HA SV serviceability is checked.

#### d) PPI, alarm and I&C serviceability is checked.

#### Second stage ECCS hydraulic accumulators:

#### a) each of eight ECCS hydraulic accumulators (TH16,17,26,27,36,37,46,47B001) is under pressure of the nitrogen blanket 2,5 MPa and filled up to nominal level 10130±100 mm with the boric acid solution with concentration at least 16 g/kg;

#### b) shut-off valves are serviceable, all its interlocks are activated;

#### c) check valves are serviceable;

#### d) safety valves are adjusted and serviceable.

e) check is performed at second stage ECCS HA flushing to the reactor.

#### 5) Serviceability of all BRU-A is checked.

#### 6) Channels of the ionizing chambers are checked for tightness.

#### 7) Water chemistry of the primary and secondary circuits is brought into compliance with the requirements specified in Appendix F.

#### 8) The SG level meters are checked for correctness of readings.

9) CPS CR drop time have been checked. CPS CR drop time is within 1,2 – 4 sec.

#### 4.1.3.2 Condition of the main schematic diagram of the Unit, as well as the equipment and systems for the Unit house-load power supply.

#### 1) The set of the activated main schematic diagram equipment shall provide for generating full NPP power to the grid.

#### 2) The protection, control, monitoring and automatics systems including circuit breaker failure back-up units are in operation with the design setting parameters at the activated main schematic diagram equipment.

#### 3) The unit transformers run the house-load of the Unit, and the redundant HL 10 kV mains are energized from the standby auxiliary transformer (SAT).

#### 4) 10 kV sections of normal operation BA, BB, BS, BD, BE, BF are fed from the auxiliary transformers (AT). The circuit breakers of the standby bushings of these sections are ready for operation with the relevant ALT, control and protection units.

#### 5) 0,66 kV 0,4 kV sections are fed by the operating bushings. The circuit breakers of the standby bushings are ready for operation with the relevant ALT, control and protection units.

#### It is allowed to feed one section in each group by the standby bushing.

#### 6) The elements of HL power supply system (including feeding elements - AT, SAT) and HL consumers are ready for operation with the required setting parameters of the protection, control, monitoring and automatics systems and supporting systems (ventilation, conditioning lighting, etc.), as well as fire alarm and automatic fire fighting.

#### 7) Direct current boards are fed by the regular circuits, the storage batteries are completely charged and are in flotage mode.

#### 8) MCR and ECR power supply is provided by the regular circuit, power is supplied to the local control boards by the Unit systems.

#### 9) Operating and emergency lighting of MCR and ECR is provided from the operating and standby feeding sections.

#### 4.1.3.3 The emergency power supply system condition

#### 1) All four EPSS channels are in operation. Power is supplied to the first and second group safety system consumers via the operating bushings of 10 kV sections and from the normal operation sources and further by the regular circuit at 0,66 kV, 0,4 Kv sections and DCB.

#### 2) The protection, control, monitoring and automatics systems of EPSS electrical equipment and current collectors of the first and second group safety systems are ready for operation with the required setting parameters (instrumentation and control devices and control units required for EPSS to perform its safety functions refers to the safety system elements).

#### 3) All EPSS electrical equipment and safety systems consumers passed maintenance in the full volume as per the requirements of the regulatory documents.

#### 4) Diesel-generator stations (SDGS) and their auxiliary systems are checked and kept in permanent readiness to the automatic or remote startup and automatic load taking.

#### The diesel fuel and oil feed tanks of each SDGS are filled up to the nominal level (the diesel fuel feed tank contains 8 m3stock of fuel, there is an unconfined space in the pure oil tank and drainage tank). At the main NPP warehouse the stock of diesel fuel shall be stored providing for operation of all SDGS within at least seven days. The oil storage tank shall have oil stock providing for SDGS operation within 12 days.

#### 5) The automatics of the sequential load ascension circuit (ASS) is ready for operation.

#### 6) Storage batteries are completely charged are in flotage mode.

#### 7) UPS maintenance is performed. All UPS are switched by the regular circuit, UPS rectifiers run load of the direct current boards and SB floating.

#### 8) Four EPSS safety channels are checked for serviceability and readiness for performing the design functions by testing and checking as per the working programs with the activated automatics of the sequential load ascension.

#### 9) Condition of all EPSS equipment shall provide for reliable power supply of the safety system current collectors in all design modes of NPP Unit with the voltage and frequency variations permissible as per the design.

#### 10) The premises where EPSS equipment is located shall meet the requirements of the existing regulatory documents, TU and manufacturer instructions for the installed equipment. Air temperature and humidity shall be maintained within the regulatory limits.

#### 11) Unauthorized access to the premises and structures where EPSS elements are located shall be restricted by the technical and organizational measures.

#### 4.1.3.4 Four ECCS channels with the high pressure pumps shall be checked for serviceability and ready for operation including:

#### 1) four pumps of the emergency boron injection TH15,25,35,45D001, as well as the system valves, I&C, interlocks and alarm.

#### 2) four pumps of the extra borating system TW10,20,30,40D001, as well as the system valves, I&C, interlocks and alarm.

#### 3) in tanks TH10,20,30,40B001,002 the design stock of the boric acid solution is arranged (not less than 197,5 m3 per each with boric acid concentration as 16-20 g/dm3.

#### In tanks TB20B001,002 the design stock of the boric acid solution is arranged (not less than 60 m3 at boric acid concentration as 39,5÷44,5 g/dm3). Two pumps TB21,22D001 are in serviceable condition.

4) In tanks TW10,20,30,40B003,004 the design stock of the boric acid solution is arranged (not less than 4,0 m3 per each with boric acid concentration as 39,5÷44,5 g/dm3).

#### 4.1.3.5 Four ECCS channels with the low pressure pumps shall be checked for serviceability and ready for operation including:

#### 1) four pumps of the emergency and scheduled primary circuit cool down TH10,20,30,40D001;

2) four heat-exchangers of emergency and scheduled primary circuit cool-down and fuel pool cooling TH10,20,30,40B003;

#### 3) the system valves, process protections and interlocks, alarm, I&C.

#### 4.1.3.6 Four channels of the sprinkler system are checked for serviceability and ready for operation:

#### 1) the system valves, I&C, alarm and interlocks;

#### 2) in each chemicals storage tank for the sprinkler system TH10,20,30,40B004 at least 3,32 m3 of solution is prepared meeting the requirements on quality specified in Appendix F.

#### 4.1.3.7 Emergency feed water system RS is checked and ready for operation including:

#### 1) four EFWP pumps RS12,22,32,42D001;

#### 2) four demineralized water storage tanks RS10,20,30,40B001, volume of distillate in each tank is 350 m3, meeting the requirements on quality specified in Appendix F;

#### 3) the system valves, process protections and interlocks, alarm, I&C serviceability is checked.

#### 4.1.3.8 Nuclear component cooling system (TF) is in serviceable condition including:

#### 1) pumps TF10,20,30,40D001, TF11,21,31,41D001, TF21,31D002;

#### 2) four heat-exchangers TF10,20,30,40B001;

#### 3) the system valves, process protections and interlocks, alarm, I&C;

4) surge tanks, closed-circuit water after-cooler.

#### The nominal level of distillate is maintained in the pressure-relief tanks. Intermediate circuit water quality corresponds to the defined requirements.

#### The design-defined number of the system channels is in operation as well as the set of operating equipment in the channel.

#### 4.1.3.9 Service water supply system for nuclear component cooling system TF and intermediate circuit for important consumers VJ (VE) is in serviceable condition including:

#### 1) pumps VE11,21,31,41D001;

#### 2) the system I&C, interlocks and alarm are serviceable;

#### 3) all VE system valves are serviceable.

#### VE system supporting systems are serviceable:

#### 1) mechanical cooling water cleaning facilities VA;

#### 2) mussel protection VB;

#### 3) ball-cleaning VL.

4) sea-water pre-cooling system VS.

#### The number of TF and VJ (VE) system channels defined by process requirements is in operation.

#### 4.1.3.10 The emergency fire protection system AFPS is checked for serviceability and put into operation in the full volume.

#### It is allowed to withdraw AFPS from the automated mode if there people in the premises under protection.

#### 4.1.3.11 The premises where SS equipment is located shall be closed against access of the unauthorized persons.

#### 4.1.3.12 Serviceability of the ventilation systems providing for normal functioning of SS equipment being in operation or standby shall be checked, namely:

* eight recirculation cooling systems for intermediate circuit pump compartment and emergency boron injection in ZB building (TL08D014, D017, D018, D021, D023… D026) are in serviceable condition;
* four recirculation plants for the primary circuit cool down compartments in ZB building (TL08D015, TL08D016, TL08D019, TL08D020) are in serviceable condition;

#### - four recirculation cooling plants for the heat-exchangers compartments of the important consumers cooling system (TL08D039…TL08D042) are in serviceable condition;

#### - eight recirculation cooling plants for the cable compartments in ZB building (TL08D002…TL08D009) are in serviceable condition;

#### - four recirculation cooling plants for the boric acid tanks compartment in ZB building (TL08D010…TL08D013) are in serviceable condition;

#### - four plants of the emergency exhaust system for creating rarefication in the annulus of ZB building (TL10D001…TL10D004) are in serviceable condition;

#### - eight recirculation cooling plants for the safety channels compartments of the steam chambers (UV13D001… UV13D008) are in serviceable condition;

#### two plants of the MCR habitability system (UV21D008, UV22D008) are in serviceable condition;

#### - four plants of the air conditioning system in MCR premises (UV21D006, UV21D007; UV22D006, UV22D007; UV23D006, UV23D007; UV24D006, UV24D007) are in serviceable condition;

#### - four plants of the MCR cable floor ventilation system (UV21D005, UV22D005, UV23D005, UV24D005) are in serviceable condition;

#### - two plants of the ECR habitability system (UV31D008, UV32D008) are in serviceable condition;

#### - four plants of the air conditioning system in ECR premises (UV31D006, UV31D007; UV32D006, UV32D007; UV33D006, UV33D007; UV34D006, UV34D007) are in serviceable condition;

#### - four recirculation cooling plants for the important consumers pumps compartments in ZМ building (UV11D010… UV11D013) are in serviceable condition;

#### - four plants of cold-air supply system for the ventilation units in the safety channels compartments (UF40, UF50, UF60, UF70) are in serviceable condition.

#### 4.1.3.13 I&C providing for SS functional mechanisms control, monitoring and protection are put into operation.

#### 4.1.3.14 Integrity of the containment is provided as follows:

#### - at least one door of each personnel lock is tightly closed;

#### - at least one hatch of the material lock is tightly closed;

#### - at least one of two interlocked doors to the annulus is tightly closed;

#### - each containment isolation valve is serviceable, or closed and tripped, except for the constantly open valves;

#### - all hand-operated containment isolation valves and plugs are closed except for those mounted to the I&C pulse lines.

#### 4.1.3.15 The Unit I&C are activated (including MCDS, RCS, ACS). The Unit parameters measuring and recording is provided in the full volume at the MCR, ECR and local control boards.

#### 4.1.3.16 PPI setpoints and the Unit equipment interlocks setpoints are checked for activation and correctness. PPI of the actuated equipment shall be in operation. The devices which activate protections (if any) and change setpoints shall be closed and sealed.

#### 4.1.3.17 The valves and its control circuit are checked for functionality, the possibility to control the valves from MCR and ECR is checked.

#### 4.1.3.18 The unit equipment safety valves are checked ad ready for operation.

#### 4.1.3.19 Four channels of the spent fuel fuel pool chilling system with pumps TH18,28,38,48D001 are ready for operation.

#### One channel is running for chilling the fuel pool.

#### It is allowed to terminate FP cool down for the time of making switchovers at the fuel pool chilling system, but no longer than for three hours at BAS temperature in FP not more than 70 °С.

#### 4.1.3.20 make-up and blow-down system (TA) is in operation, including:

#### 1) two pumps TA31(32,33)D001 are serviceable;

#### 2) make-up deaerator is serviceable;

#### 3) heat-exchangers TA10B001,002, TA21,22B001 are serviceable;

#### 4) serviceability of valves, protections and interlocks, regulators, alarm, I&C is checked.

#### 4.1.3.21 The primary circuit blow-down purification system ТС is ready for startup. Anion-exchange charging of TC system MBF (operating and standby) shall be saturated by boric acid at primary circuit water-exchange.

It is allowed to startup anion-exchange filter TC16B001 unsaturated with boric acid, only prior commencement of boron removal at the end of the reactor fuel cycle.

TC system filters-traps, I&C and alarm are serviceable.

#### Grained material traps are serviceable, as well as valves, I&C and alarm.

#### 4.1.3.22 Coolant storage and treatment system TD is in operation. Unconfined space is prepared (at least 240 m3) in the tanks to intake the discharged primary circuit waters. Pumps TD71,72,73D001, TD21,22D001 are ready for operation. Filters TD31B001,002 are in serviceable condition (TD31B001 regenerated, if required). TDsystem filters-traps, I&C and alarm are serviceable.

#### 4.1.3.23 Not less than 200 m3 of distillate is prepared in the tanks TD14,15,16B001. Distillate quality corresponds to the normative (Appendix F, Table F.11). Distillate pumps TD71,72,73D001 are ready for operation. Serviceability of valves, PPI, alarm is checked. The measures are taken to prevent distillate ingress to the primary circuit coolant (as per OI RP).

#### 4.1.3.24 The radioactive sampling system (TV) and process fluid sampling system of the secondary circuit are in operation, including:

#### 1) the automated primary circuit water chemical monitoring system;

#### 2) the automated secondary circuit water chemical monitoring system.

#### 3) laboratory control performed according to approved regulation of chemical control of process fluids of BNPP-1;

The system of the primary circuit automated control (TV60-80), operating in the automatic mode maintains a continuous control of water chemistry condition of the primary circuit coolant (concentrations of boric acid, hydrogen, oxygen, specific conductance).

#### 4.1.3.25 Nuclear equipment drain system in reactor compartment (TY-1) and in ZC building (TY-2) are in operation. Controlled leakage tank TY30B001 and drain tanks TY21,22B001 are blown-down with nitrogen due to functioning of the hydrogen afterburning system blowers. Serviceability of the controlled leakage pumps TY31,32D001 and drain pumps TY21,22D001 is checked, as well as valves, PPI, alarm, I&C. Primary circuit controlled leakages heat-exchanger TY10B001 is serviceable.

#### 4.1.3.26 The system of preparation and injection of chemical agents to the primary circuit (ТВ) are in operation. Storage tanks of potassium hydroxide, hydrazine hydrate and ammonia are filled with nominal volumes of chemical agents to main water chemistry of the primary circuit coolant.

#### 4.1.3.27 The special gas treatment and hydrogen afterburning system is in operation as per the design circuit:

#### 1) one of two hydrogen afterburning system channels (TS10);

#### 2) one of two gas treatment system process channels TS20.

#### 4.1.3.28 Nitrogen supply is provided to all consumers. The nitrogen receivers have the operational margin at the design pressure.

#### 4.1.3.29 ICIS system is ready for operation. Control and recording of the parameters included into ICIS archive is provided.

#### 4.1.3.30 House-load system is supplied with steam from the common plant header (or from the AB). The possibility is provided to supply steam to all consumers in the required amount and with the proper parameters.

#### 4.1.3.31 Ventilation systems are serviceable and activated:

#### 1) recirculating cooling system for the reactor cavity, SG box and RCPS TL03;

#### 2) recirculating central hall cooling system TL05;

#### 3) recirculating CPS drives cooling TL13;

#### The valves, I&C, alarm, protections and interlocks supporting serviceability of the a.m. systems are functional.

#### 4.1.3.32 AWT facilities equipment condition shall meet the following requirements:

#### 1) liquid wastes disposal system TR, fuel pool water treatment system TG, coolant storage and treatment system TD, fuel pool water discharge system TH50-70are prepared for operation as per the design.

#### The possibility of regenerating these plants’ filters is provided.

#### 2) at least a half the of the volume of the drains tanks ТR11-15В001 are emptied and ready to intake media.

#### 4.1.3.33 The secondary circuit water chemistry maintaining systems are serviceable:

#### 1) RZ – steam-generator blow-down system;

#### 2) UZ – steam-generator blow-down water treatment system;

#### 3) UB – turbine condensate demineralizing system;

4) UA – demineralizing system;

5) UD – demineralized water system;

1. UH10 – hydrazine preparation and dosing system;
2. UH40 – ammonia preparation and dosing system;
3. RF60B001 – deaerator;
4. RV –secondary circuit sampling system.

Water quality in deaerator shall correspond to the normative indices specified in Appendix F. Two AFWP and at least two FWP are ready for operation.

#### 4.1.3.34 Drains treatment system TR and concentrated wastes treatment system ТТ is in operation.

#### 4.1.3.35 Catalytic hydrogen recombiners XP are in serviceable condition. Hydrogen concentration monitoring system in the containment is in serviceable condition.

#### Instrumentation air system for air-actuated valves is in operation. Two high pressure compressor plants (TM) are ready for operation to maintain the design pressure in the instrumentation air receivers. The instrumentation air supply is provided to control the air actuators of the valves.

#### 4.1.3.36 The emergency primary circuit gas removal system (YR) is ready for operation.

#### 4.1.3.37 Two pumps TB21,22D001 are in serviceable condition.

#### 4.1.3.38 Four legs of the non-cooled coolant treatment system ТС60,70,80,90 are in operation.

#### 4.1.3.39 All NFME channels are serviceable. The control for the reactor power excursion period and neutron power is provided. The power excursion audible warning devices are switched on. Period protection setpoints are set to position EP: PP-20 sec: 40 sec, and power setpoints are not higher than 10-3 % Nnom.

4.1.3.40 Water chemistry of the primary and secondary circuits corresponds to water chemistry requirements specified in Appendix F.

4.1.3.41 Measures are taken to avoid coolant ingress to the primary circuit at boric acid concentration less than 16 g/dm3.

**4.1.4 The Unit safety operation conditions at the reactor bringing to minimally-controlled level of power**

4.1.4.1 Ambient temperature of NITC electric connectors at operation shall not exceed 105°С. Short-time temperature increasing is allowed within not more than 6 minutes up to 200 °С.

4.1.4.2Steam blanket without nitrogen admixtures shall be created in the pressurizer prior the reactor bringing to MCL, PRZ level shall be not less than 5100±150 mm (level calculation from the bottom internal generatrix of PRZ shell), pressure is 15,7 MPa (160 kgf/cm2).

4.1.4.3 Each ECCS hydraulic accumulator shall be filled with boric acid solution at concentration not less than 16 g/kg up to level (6500±100) mm, pressure is 6±0,10,3 MPa   
(60±13 kgf/cm2). Temperature in the hydraulic accumulators shall be within 65-75оС.

4.1.4.4 Pressure in intergasket space of SG, PRZ, RCPS, ECCS HA of the 1st stage and reactor flange joints is not available.

4.1.4.5 At the Unit changeover to the minimally-controlled level of power, the Unit safety operation conditions specified in section 4.1.3 of the technical specification shall be fulfilled.

4.1.4.6 Fluctuation of primary circuit water temperature shall not exceed the range of (260÷280) °С.

4.1.4.7 At unavailability of the approved procedure, pure condensate permissible flow-rate within startup interval shall be not more than 6,5 t/h.

4.1.4.8 Data on the reactor core neutron-physical characteristics are available. Album of neutron-physical characteristics is submitted to MCR. Starting boric acid concentration in primary circuit coolant has been calculated.

4.1.4.9 Extraction of CPS CR groups at reaching MCL of power (at the Unit changeover from condition 3 to condition 2) shall be performed by-turns for 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 CPS CR groups starting from group 1, by pitches per 10 % (35 cm) with time delay between the pitches al least 60 sec at stable NFME readings. Groups 1, 2, 3, 4, 5, 6, 7, 8, 9 shall be extracted

to ULLS, group 10 shall be extracted up to 60 % position. Boric acid concentration decreasing in the primary circuit coolant is allowed only after CPS CR groups extraction completion.

4.1.4.10 Four RCPS are in operation.

4.1.4.11 Boric acid concentration is within 16 g/kg up to the concentration corresponding to the critical condition.

4.1.4.12 CPS check is completed.

4.1.4.13 Nuclear safety department performed evaluation of subcriticality degree and reactivity margin by NPC album data prior the reactor brining to the critical condition after refueling, after overhaul or intermediate maintenance as well as after idling in standby during more than three days.

4.1.4.14 Reactor CPS serviceability is performed.

CPS electrical part is checked.

Operability of CPS CR was performed in the mode of group drop, CPS CR dropping time is (1,2÷4) sec.

4.1.4.15 Anion-exchange charging of mixed-bed filters TC11,12B001 is saturated during water-exchange.

**4.1.5 The Unit safety operation conditions at the minimally-controlled level of power**

#### Parameters characterizing the Unit at MCL are specified in item 2.2.2.2. Condition of the Unit equipment shall meet the requirements subjected to the equipment in «hot» standby mode (see item 4.1.3). Additionally to the requirements stated in item 4.1.3, the below mentioned requirements shall be performed.

#### 4.1.5.1 The reactor plant equipment condition.

#### 1) The pressurizing system is in operation:

#### а) PRZ is in steam mode. PRZ level is (5100±150) mm. The PRZ level maintaining control device is set to the automatic mode.

#### PRZ level meters functioning check is performed by comparing the readings of the different level meters (the readings difference shall not exceed two errors of the level meters measurements).

#### b) PRZ PSD serviceability is checked. PRZ PSD PPV springs are adjusted. The adjustment unit is sealed.

#### 2) The steam-generators are ready for operation.

#### а) Level in each SG is nominal (2400±50) mm. SG level meters reading are checked for correctness.

#### b) SG blow-down system is in operation, providing for continuous and periodic blow-downs of all four SG and continuous heat-up of the pipelines.

#### c) SG SV serviceability is checked. SG PSD are set and sealed.

#### 3) Tightness of the 1st and 2nd stage ECCS HA check vales is checked.

#### 4) All MSIV are checked for serviceability and ready for operation.

#### 4.1.5.2 The systems of the generated steam relief via the secondary circuit are serviceable:

#### 1) Serviceability of all BRU-A RA10,20,30,40S003 is checked;

#### 2) Both or one of the systems (BRU-K or BRU-SN) respectively consisting of:

#### а) all BRU-K SF11-16S001 if there is vacuum in the condenser;

#### b) BRU-SN RA57S003;

#### 3) The valves, I&C, regulators, interlocks and alarm supporting serviceability of the enumerated equipment.

4.1.5.3 Boric acid concentration corresponds to the critical condition.

* + - 1. CPS CR adherence to their drives is checked.
      2. Activities on experimental determination of the core neutron-physical characteristics have been performed. The obtained results corresponds to the design values within errors range.
      3. At the reactor power decreasing up to 10-4 Nnom level, the personnel shall introduce the source range chambers to the maximal sensitivity zone.
      4. Primary and secondary circuit water chemistry corresponds to the requirements of water chemistry norms specified in Appendix F.
      5. Anion-exchange charging of TC11,12B001 mixed filters is saturated and one of the filters is in operation.
      6. ASBE priority switches of 10 kV NO sections 10ВА, 10ВВ, 10ВС, 10BD are set to the position, ensuring ASBE priority on the section 10BA, 10 BC. In case of failure of EFP 10RL22D001 (repair, defect, preventing its operation) ASBE priority switches of 10 kV NO sections НЭ 10ВА, 10ВВ, 10ВС, 10BD shall be set in the position, ensuring ASBE priority at the section 10BB, 10BD.

Setting of priority switches shall be performed by EE SS by order of PSS with a record in the operating logbook of their actual position.

**4.2 Sequence of actions and the main safety operation methods at the Unit heat-up and startup**

**4.2.1 The Unit changeover from “refueling" condition to "cold" condition**

#### 4.2.1.1 It is allowed to changeover the Unit from “refueling" condition to "cold" condition after:

1) Fulfilling the requirements to the equipment and systems condition listed in item 4.1.1.

The Unit equipment and systems shall be operated as per the requirements of the operating instructions on the equipment and systems, design and manufacturing documentation. At the equipment and systems preparation for startup, all APCS/TLSU subsystems, EP/PP, CPS EE, MCDS, ESFAS, LMS-H, I&C-AWT, I&C-RC, I&C-TC AFPS/including I&C, protections interlocks, automatic control and alarm shall be checked and started up. An exception is a part of maintenance automation systems do not involved into activities at these stages. At reaching primary circuit temperature 200 °С, it is required to makes sure additionally in unavailability of error signals and check compliance of the main parameters readings at the devices and displays and individual devices.. Check of the equipment, process protections, interlocks and alarm for serviceability shall be recorded in the reports (Acts) in the “Log-book of Acts” and “Log-book of PPI checks” at MCR by measure of putting the equipment into operation, to standby.

2) Performance of checks during preventive maintenance.

The scope of the equipment and systems checks and tests to be performed during preventive maintenance is listed in section 10.2.

3) Confirmation from the heads of subdivisions on readiness of the equipment, documents, personnel for the primary circuit hydraulic testing at 3,4 MPa (35 kgf/cm2), the secondary circuit at 1,96 MPa (20 kgf/cm2), obtaining the permit from the deputy chief engineer on operation for commencement of operations on the Unit changeover from “refueling" condition to “cold” condition and for the primary and secondary circuits hydraulic testing recorded in the “Log-book on the technical directives” at SSU workplace.

#### 4.2.1.2 The reactor assembling

1) Check the core loading correctness as per the approved map of the regular fuel loading using RM video-camera.

2) Check height-wise layout of FA caps.

Difference in height of FA caps of one and the same operation year shall be not more than 5 mm.

3) Using video-camera and refueling machine, inspect the core and make sure in unavailability of extraneous objects and damages and in correctness of FA, CPS AR and CPS bundles loading and arrangement.

4) Mount PTU to the reactor. Measure the distance from the lower PTU pads up to the thrust face of IVP. The measured distance shall be within the range from 15 to 20 mm. At this criterion non-conformance, adjust PTU pads.

5) Mount UU, perform assembling and sealing of the reactor main joint and the primary circuit equipment.

6) Perform adhesion of CPS drive bars with CPS AR.

Check correctness of the bar adhesion to CPS AR by:

а) change of bar latch key BU 407.503.09.07 position relatively bar key BU 407.503.09.22;

b) availability of CPS AR weight at lifting the assembly “KEY+BAR+CPS AR” to 50…100 mm manually.

Perform dragging of the bar with CPS AR per (3400÷3500) mm, measuring by the dynamometering unit the forces required for CPS AR displacement up and down which shall be not more than 440 N at upward motion, and not less than 240 N at downward motion. Acceptance criteria is friction force value not more than 100 N.

Lifting of assembly “ KEY+BAR+CPS AR” shall be performed at the coolant level in the reactor to (200÷400) mm lower the reactor main joint.

Perform installation and sealing of CPS drive PPS.

7) Connect electrical connectors to CPS drives.

8) Perform electrical connection with ICIS (SHWC-3) equipment using ICDS plugs and LIE.

9) Mount preventive sleeves and the cross-arm to UU.

10) Mount:

- hydroseal of the spent fuel pool No. 1 between the spent fuel pool and the reactor internals inspection pool;

- hydroseal of the spent fuel pool No. 2 (protective) between the spent fuel pool and the reactor internals inspection pool;

- hydroseal of the spent fuel pool container section between the spent fuel pool and the container section.

- large hydroseal between the reactor cavity and reactor internals inspection pool.

#### 4.2.1.3 Primary circuit refilling

1) Prior to the primary circuit refilling, make sure that boric acid solution quality in tank TD11B001 (if required, in tanks TD11,12,13B001) corresponds to the requirements specified in Appendix F. (BAS concentration is 16-20 g/dm3. Temperature is 20 – 60 ºС).

Primary circuit refilling shall be performed by pumps TA31,32,33D001.

Primary circuit refilling shall be performed at the opened MCC and RP equipment air vents.

2) At the reactor refilling, water flow-rate shall not be more than 40 m3/hr, and at PRZ level from 5100 mm – not more than 20 m3/hr, and at PRZ level from 11000 mm – not more than 10 m3/h.

Prior to the primary circuit refilling, supply sealing water to RCPS.

Do not supply water for RCPS rinsing of boron.

It is allowed to supply water for RCPS seals rinsing of boron crystals before RCPS actuation (the primary circuit pressure is not less than 0,98 MPa (10 kgf/cm2).

1. Perform primary circuit filling monitoring by level in PRZ and the reactor, as well as by unavailability of signalization on coolant level availability under the reactor top head by LIE readings.

4) Perform filling of the non-cooled coolant clean-up system (ТС60-90) equipment in the process of the primary circuit filling.

To avoid accidental hydraulic unloading of sorbent by the coolant backflow, perform ТС60-90 filling by opening bypass of valves ТС60,70,80,90S002 at the closed ТС60,70,80,90S001,004.

5) Perform closing of the primary circuit air vent valves upon 30 minutes expiration after appearing of the stable noise at the corresponding air vent and in case of stable level increase in the tank TY30B001 for 30 min.

6) At PRZ level 12400 mm and appearing of the stable noise at the PRZ air removal line and stable level increase in the tank TY30B001 within 30 minutes, complete primary circuit filling as per the operating instructions on the primary circuit equipment – close PRZ air vents.

7) Upon completion the primary circuit refilling, increase primary circuit pressure up to 0,5 MPa (5 kgf/cm2) by pump TA31(32,33)D001 operation.

4.2.1.4 Primary circuit hydraulic tests by pressure 3,4 MPa (35 kgf/cm2).

1) At pressure 0,5 MPa (5 kgf/cm2), perform air removal from all primary circuit air vents. Perform the primary circuit equipment inspection in order to reveal any leaks.

2) Prior to increase the primary circuit pressure over 1,8 MPa (18,4 kgf/cm2), reliably disconnect all low pressure pipelines of the auxiliary systems from the high pressure pipelines using the interfacing valves.

Disconnection of low pressure pipelines shall be performed as per the special list of the interfacing valves and the relevant record shall be made in the operative log-book of SSRC, SSU.

3) Disconnect the scheduled cool down system from the primary circuit.

During the period when the forced circulation through the reactor core is terminated, control availability of natural circulation through the core (see Appendix G) and availability of at least 15 °С margin before boiling up at the FA outlet.

4) Increase primary circuit pressure up to 3,4 MPa (35 kgf/cm2) and perform air removal from RCPS off-line circuit.

Pressure variation rate in the reactor shall be not more than 0,5 MPa (5 kgf/cm2) per minute.

Pressure increasing in the reactor shall be performed taking into regard the limits specified in Appendix H.

5) At pressure 3,4 MPa (35 kgf/cm2), perform inspection of the primary circuit equipment in order to reveal any leakages. Control absence of pressure in the inter-sealing space of the reactor joints, PRZ, SG, RCPS. Check absence of leakages through the internal gaskets of the CPS drive, ICDS, TC60-90 filters flanged connections. At availability of leaking, drop the pressure, eliminate them and repeat testing for tightness.

6) Decrease the primary circuit pressure up to 2,4 MPa (25 kgf/cm2) for all period of the secondary circuit testing by pressure 1,96 MPa (20 kgf/cm2).

#### 4.2.1.5 Filling SG by the secondary circuit

1) Check the secondary circuit interfacing valves condition as per the approved program. Disconnect the low pressure pipelines of the secondary circuit auxiliary systems.

2) Perform SG filling up to 3700 mm level by the secondary circuit at the opened air vents by pumps RR12,22D001 from the deaerator and complete it prior to the primary circuit testing for tightness at pressure 3,4 MPa (35 kgf/cm2).

Perform SG filling by demineralized water. Water quality shall meet the requirements specified in Appendix F. Water temperature is (20÷60) °С and shall not differ from SG metal temperature to more than 60 °С.

In accordance with the hydraulic testing program, it is required also to fill the steam-lines, feed water pipelines, blow-down lines up to the first shut-off valves until water appeared from the secondary circuit air vents.

4.2.1.6 Secondary circuit hydraulic tests by pressure 1,96 MPa (20 kgf/cm2).

1) Sequentially increase the secondary circuit pressure up to 0,5 MPa (5 kgf/cm2) and 1,96 MPa (20 kgf/cm2), inspect the secondary circuit equipment in order to reveal any leakages.

At the secondary circuit hydraulic testing, it is forbidden to decrease the primary circuit pressure lower the secondary circuit pressure due to nuclear safety conditions to avoid “pure” condensate leakage from the secondary circuit to the primary one.

Prior to the secondary circuit pressure increasing over 1,5 MPa (15 kgf/cm2), check reliable disconnection of the low pressure and high pressure pipelines. Pressure increasing shall be performed at the rate not more than 0,98 MPa/min (10 kgf/cm2/min)

2) Decrease pressure and drain off the secondary circuit up to (3700÷3800) mm level in each SG.

3) Decrease the primary circuit pressure up to (1,47-1,96) MPa ((15÷18) kgf/cm2) and connect the residual heat removal and cool down system TH to the primary circuit.

#### 4.2.1.7 Upon completion of above mentioned works, put into operation (standby) the equipment required for the Unit heat-up up to the hydraulic testing or testing for tightness parameters (see section 4.1.2), perform the required tests and checks.

#### 4.2.1.8 In accordance with the approved program, perform checks and tests of the equipment and systems in the scope defined in section 10.

#### 4.2.1.9 When the Unit is in “cold” condition, the operative personnel have to:

1) Monitor by NFME the reactor power excursion period and the neutron flux level.

2) Monitor boric acid concentration in the primary circuit and maintain its value not lower than the steady one. In «cold» condition, boric acid concentration shall be 16÷18 g/dm3.

3) Monitor operating media quality in the primary and secondary circuits (see Appendix F).

4) Monitor temperature at FA outlet, not allowing its increasing over 80 °С, as well as monitor the primary circuit temperature by “hot” legs of loops, not allowing its increasing over 70 °С or decreasing below 20 °С, and the reactor vessel metal temperature.

5) Monitor the primary circuit pressure by indications за YC00P903,904,905,906 and do not allow its increasing over (1,47-1,8) MPa ((15÷18,4) kgf/cm2) at the emergency and scheduled cool down system connected to the primary circuit.

At testing for tightness in “cold” condition, the primary circuit pressure shall not exceed 3,4 Mpa (35 kgf/cm2).

At the primary circuit increasing higher than 1,8 MPa (18,4 kgf/cm2), it is required to provide for reliable separation of the low pressure and high pressure pipeline sections and introduce the relevant records to the operative log-books.

6) Control fulfillment of measures on elimination of water ingress to the primary circuit with the boric acid concentration lower than the circuit one (as per OI RP) every shift, recording the control results in the operative log-books.

7) Control the secondary circuit pressure, not allowing its increasing over 1,8 MPa (18,4 kgf/cm2). Due to nuclear safety conditions, the secondary circuit pressure shall not be higher than the primary circuit pressure.

8) In accordance with the approved schedule, perform trial of the equipment and systems being in operation, in standby as per the «Schedule of changeover to the standby equipment and testing the automatic load transfer».

9) Check readiness of EPSS channel systems and elements to perform the design functions.

10) Check that the equipment and systems passed testing and checks in the scope defined in section 10.2.

11) Provide readiness of all systems for operation due to the process necessity of their use and as per the manufacturing instructions.

**4.2.2 The reactor plant heat-up up to the hydraulic testing temperature**

#### 4.2.2.1 It is allowed to actuate RCPS and heat-up RP up to the hydraulic testing parameters provided that:

1) The checks to be performed in “cold” RP condition are completed.

The scope of the equipment trial and testing to be performed in “cold” condition of the Unit is specified in section 10.2.

2) The permit for the primary and secondary circuit hydraulic testing is obtained.

Prior to RP heat-up commencement, the heads of subdivisions performing operation, maintenance and monitoring for the equipment and system condition, shall make a note in “Log-book of the technical directives” on readiness of the equipment, documents and the personnel to the hydraulic testing.

The permit for RP heat-up up to the hydraulic testing parameters and the primary and secondary hydraulic testing shall be recorded in the “Log-book of the technical directives” at SSU workplace signed by the deputy chief engineer on operation.

#### 4.2.2.2 The primary and secondary circuit heat-up up to the hydraulic testing temperature.

1) Disconnect the residual heat removal and RP cool–down system form the primary circuit.

2) Create nitrogen blanket in PRZ at the following parameters:

a) primary circuit pressure - 1,8 MPa (18,4 kgf/cm2);

b) PRZ level - (11100±100) mm (level calculation from the bottom internal generatrix of PRZ shell).

Prior to pressure increasing in the primary and secondary circuits over   
1,8 MPa (18,4 kgf/cm2) as per the testing programs, install the equipment separating the low pressure and high pressure pipeline sections to the relevant position (including the valves isolating the residual heat removal and primary circuit cool–down system), disassemble the electric circuit of the gate valves power supply and implement the measures on disabling control for this valves.

At the operating Unit, the control and interlocks for the a.m. valves may not be checked.

3) Turn on two vent units TL13. Supply power to CPS drives and to CPS drive control system. Take up CPS CR in turn up to activation of the bottom limit stop switches.

4) Turn on two opposite RCPS in turn as per the operating instruction.

Provide for reliable primary circuit air removal at first RCPS actuation after primary circuit filling.

Primary circuit heat-up shall be performed due to RCPS operation, residual heat of the reactor core and PRZ electric heaters operation.

At the primary circuit temperature less than 200 °С, operation of more than three RCPS is forbidden.

At the primary circuit coolant temperature more than 60 °С, intermediate circuit water shall be supplied to RCPS.

5) The following restrictions shall be observed during heat-up:

а) primary circuit coolant heat-up rate – not more than 20 °С/hr;

b) the margin up to boiling up at the primary circuit coolant temperature at the core top - not less than 15 °С;

c) temperature difference between PRZ water and primary circuit coolant – not more than 5 °С.

If PRZ water temperature is higher than the primary circuit coolant temperature, don’t turn on PRZ TEH. If necessary, maintain the permissible temperature difference between PRZ water and primary circuit coolant by actuating PRZ cool down regulator. Open PRZ injection valves after balancing the primary circuit coolant and PRZ temperatures.

d) RP equipment metal temperatures during hydraulic tests and leaktigtness tests shall be not less than those specified in i. 3.2.2.5.

e) maximum permissible pressure in the modes of the planned heating and cooldown from the view of brittle failure resistance shall be identified depending on the coolant temperature according to the schedules given in Appendix H.

6) After coolant heat-up up to 80-90 °С temperature, oxygen concentration shall be decreased due to hydrazine-hydrate injection to the primary circuit in the amount providing its double or triple excess relatively oxygen concentration. Hydrazine-hydrate injection shall be continued until decreasing oxygen concentration in the coolant up to the values scheduled by primary circuit WC norms.

7) Heat-up dead-end sections of ECCS passive part pipelines up to the temperature not less than 30 °С.

Open valves on the drainage between the shut-off gate valves Dnom 300 of ECCS passive part and on the bypass of the check valves, control closing the second gate valve counting from the reactor and open the first gate valve Dnom 300 counting from the reactor.

8) TC60-90 system hydraulic testing and heat-up shall be performed jointly with the primary circuit.

9) Control the primary circuit equipment metal heat-up up as per item 3.2.2.5 to the minimal temperature, at which it is allowed to increase the primary circuit pressure up to HT pressure.

10) In the process of the primary circuit heat-up, monitor the process of the primary circuit equipment (MCP, RCPS, SG) expansion by indications of hydraulic absorber position indicators.

11) In parallel to the primary circuit heat-up, start heat-up of SG blow-down system, turbine hall deaerator.

During the period, when the forced circulation through the rector core is terminated, monitor availability of the natural circulation through the reactor core and at least 15 °С margin up to boiling up at FA outlet.

12) Move CPS CR down to the stops. De-energize their drives. Turn-off two vent units TL13.

#### 4.2.2.3 Hydraulic tests of the primary and secondary circuits

1) Check the primary circuit interfacing valves condition as per the working program. Disconnect the low pressure pipelines of RP auxiliary systems. Take measures preventing against PRZ SV opening (close isolation valves, disable them and de-energize PRZ PSD PV).

2) At primary circuit pressure increasing, observe the limits specified in item 3.2.2.5.

3) Using the make up pump, increase pressure in the primary circuit by the following steps: 3,5; 10,0; 15,7; 17,6 MPa (35, 100, 160, 180 kgf/cm2) at rate 0,98 MPa/min (10 kgf/cm2 per min.), with retention at each step and inspection of the primary circuit equipment in order to reveal any leakages. Make up water temperature after regenerative heat exchanger shall be more than 65 °С.

4) At pressure 17,6 MPa (180 kgf/cm2), perform final check of the reactor plant equipment, systems and pipelines sealing in places defined by the tightness testing program.

5) Check absence of pressure in the inter-sealing space of the reactor joints, PRZ, SG, TC60-90, RCPS. Check absence of leakages through the internal gaskets of CPS drive flanged connections, LIE terminations. If any cracks, breaks, leakages, visible residual deformations are revealed, decrease pressure and after eliminating the defects, retest for tightness.

It is allowed not to blow-off the nitrogen blanket from PRZ during MCC testing only for tightness, and if the joints at PRZ PSD have not been unsealed.

6) If it is necessary to perform the primary circuit hydraulic test for strength:

а) Blow-off the nitrogen blanket from PRZ;

b) prior to start the primary circuit pressure increasing higher than 17,6 MPa (180 kgf/cm2), disconnect running RCPS and close valves at RCPS sealing water supply and removal;

c) prior to start the primary circuit pressure increasing higher than 19,6 MPa (200 kgf/cm2), disconnect PCP gauges, which are not capable to operate at pressure more than 19,6 MPa (200 kgf/cm2);

d) increase primary circuit pressure up to 24,5 MPa (250 kgf/cm2);

e) perform retention within at least 10 minutes at the primary circuit strength test pressure (totally not more than 60 minutes within operation life of each FA);

f) decrease pressure up to 19,6 MPa (200 kgf/cm2) and inspect the primary circuit equipment;

Retention time at pressure 19,6 MPa (200 kgf/cm2) is defined by the time required to perform inspection, but it shall not be less than one hour and not more than four hours.

7) If there are no defects, decrease primary circuit pressure up to 1,8 MPa (18,4 kgf/cm2). Open the valves at RCPS sealing water supply and removal. Create nitrogen blanket in PRZ and actuate at least one RCPS. Prior to RCPS actuation, supply power to CPS CR and lift them up from the stops. Connect I&C disconnected for the time of hydraulic testing to the primary circuit. Connect PRZ PSD. Increase primary circuit pressure up to 12,3 MPa (125,5 kgf/cm2) for the period of secondary circuit hydraulic testing.

8) Perform the secondary circuit hydraulic tests or tests for tightness:

a) check the secondary circuit interfacing valves condition as per the working program, disconnect the low pressure pipelines of the secondary circuit auxiliary systems;

b) refill the secondary circuit;

c) disassemble BRU-A electric circuit;

d) increase secondary circuit pressure up to 8,64 MPa (88 kgf/cm2) checking for tightness at rate 0,98 MPa/min (10 kgf/cm2 per min.);

Temperature of the secondary circuit elements wall at hydraulic testing is not less than 80°С.

At the secondary circuit hydraulic testing it is forbidden to decrease the primary circuit pressure lower than the secondary circuit pressure due to nuclear safety conditions to avoid “pure” condensate leakage from the secondary to the primary circuit.

e) if it is required to test the secondary circuit for strength:

- prior to start the secondary circuit pressure increasing more than 8,64 MPa (88 kgf/cm2), disconnect PCP gauges, which are not capable to function at pressure higher than 8,64 MPa (88 kgf/cm2);

- increase secondary circuit pressure up to 10,8 MPa (110 kgf/cm2);

- perform retention at the secondary circuit hydraulic testing at least 10 minutes;

- decrease pressure up to 8,64 MPa (88 kgf/cm2) and inspect the secondary circuit equipment;

f) if there are no defects, connect I&C disconnected for the time of hydraulic testing, drain off the secondary circuit up to (3700÷3800) mm level in each SG.

g) decrease primary circuit pressure and connect scheduled cool-down system.

#### 4.2.2.4 Upon completion of hydraulic tests or tests for tightness, start putting into operation (standby) the equipment required for “hot” standby of the Unit (see section 4.1.3), perform the required tests and checks.

#### 4.2.2.5. At the stage of RP heat-up during startup after preventive maintenance, perform checks and tests of the equipment and systems in the scope specified in section 10.2 as per the approved program.

**4.2.3 The Unit changeover to "hot" condition**

#### 4.2.3.1 The Unit changeover to "hot" condition is allowed after:

1) performing the requirements to the equipment and systems conditions specified in item 4.1.3 in the process of heating-up.

2) performing the checks and tests to be conducted during the reactor plant heat-up.

3) confirmation by the heads of subdivisions the readiness of the equipment, documents, personnel and obtaining a permit from chief engineer of NPP for the Unit heat-up up to the nominal parameters, which is recorded in the “Log-book of technical directives” at the SSU workplace.

#### 4.2.3.2 The Unit heat up to the nominal parameters

1) At the primary circuit temperature less than 200 °С, actuate not more than three RCPS. In the process of heating-up, actuate the fourth RCPS at the primary circuit temperature more than 200 °С.

2) Turn on PRZ TEH, start advanced PRZ heating-up.

3) The following restrictions shall be observed during heat-up:

a) the primary circuit coolant heat-up rate shall be not more than 20 °С/hr with monitoring for RP equipment displacement values;

b) the margin by the primary circuit coolant up to boiling up at the core top is at least 15°С;

c) temperature difference between water in PRZ and the primary circuit – not more than 55 °С, temperature difference between upper and lower PRZ bottom – not more than 85 °С;

d) the reactor cavity concrete heat-up rate – less than 10 °С/hr;

e) limits on the main equipment parameters are specified in Appendix B;

At increasing pressure above the core up to 2,94 MPa (30 kgf/cm2), maintain this pressure as constant.

During the whole process of RP heat-up the reliable air removal shall be provided from off-line circuit of each RCPS and water circulation by this circuit.

During RP heat-up, the primary and secondary circuit WC shall be corrected (Appendix F).

During heat-up the primary circuit equipment (MCP, RCPS, SG) thermal expansion shall be controlled by indications of hydraulic absorber position indicators.

4) Upon reaching primary circuit water temperature as 155°С, and in PRZ - 210 °С, replace nitrogen blanket in PRZ with the steam cushion by gas blow-off from PRZ, not allowing the relief tank membranes rupture.

5) Decrease level in PRZ up to 5100 mm corresponding to N ≤ 10 % Nnom.

After decreasing level in PRZ, it is allowed to heat-up water in PRZ at the rate 30 °С/hr due to operation of the electric heaters.

6) It is allowed to decrease water level in SG from (3700÷3800) mm to the nominal value after increasing water temperature in SG up to (100÷120) °С (at availability of boiling in SG).

7) At the primary circuit pressure 14,1MPa (144 kgf/cm2), perform PRZ PSD serviceability check as per Table 10.2.1.

8) At the primary circuit pressure 6,4 MPa (65 kgf/cm2), open the shut-off gate valves Dу 300 of the first and second stage ECCS hydraulic accumulators.

9) In parallel to the primary circuit heat-up, start prepare the turbine-generator for startup, for this purpose prepare and pt into operation its auxiliary systems:

a) circulating water;

b) oil lubricator;

c) generator shaft seal;

d) hydrostatic rotor lifting;

e) shaft turning gear;

f) turbine control;

g) vacuum system of the condensers;

h) main steam-line and BRU-K;

i) feed water;

j) HL steam-lines;

k) generator gas-cooling;

l) the main condensate;

m) turbine condensate demineralizer (UDP).

10) Prepare and startup I&C TC, TGS HP and EPCS, the generator instrumentation system. Without starting up these systems, it is not allowed to startup the turbine plant.

1. Upon reaching pressure in MSH as 5,8 MPa (58 kgf/cm2), start ERV heat-up via MSGV bypass up to increasing the temperature of the outer walls of the stop valves bodies as per OI requirements.
2. In heat-up process, don’t allow to exceed the primary circuit pressure, shown in the diagram of Appendix H.
3. ТС60-90 system heat-up shall be performed jointly with the primary circuit.
4. Prepare and switch to the standby mode DGP 10GY50 of the common plant system of reliable power supply with auxiliary systems.

#### 4.2.3.3 Perform the tests in the scope defined in Table 10.2.1 at the nominal parameters as per the approved programs.

#### 4.2.3.4 When the Unit is in “hot” condition, the operative personnel shall:

1) Monitor by NFME the reactor power excursion period and neutron flux level.

2) Monitor boric acid concentration in the primary circuit and maintain its value not lower than the steady one 16-20 g/dm3.

3) Control fulfillment of measures on elimination of water ingress to the primary circuit with the boric acid concentration lower than the circuit one (as per OI RP) every shift, recording the control results in the operative log-books.

4) Maintain the primary circuit coolant temperature at   
(260÷280) °С level by the secondary circuit steam relieving via BRU-SN or BRU-K to the turbine condenser;

5) Monitor water chemistry of the primary and secondary circuits, their auxiliary systems and perform its correction as per the requirements specified in Appendix F.

6) Control process parameters of the primary and secondary circuits, their auxiliary systems and maintain them within the limits specified in section 3 and Appendix B.

7) perform trial of the equipment and systems being in operation or standby as per the approved schedule.

8) Monitor readiness of EPSS channel systems and elements to perform the design functions.

9) Provide for readiness of all systems for operation in compliance with the process necessity for their use and the manufacturing instructions.

4.2.3.5 Primary and secondary circuit water chemistry corresponds to the requirements of water chemistry norms specified in Appendix F.

**4.2.4 The Unit startup**

#### 4.2.4.1 It is allowed to changeover the Unit to the minimally-controlled level of power after:

1) Performing the requirements to the equipment and systems conditions specified in item 4.1.4.

2) Performing the tests to be conducted during the reactor plant heat-up and in “hot” condition.

3) Confirmation by the heads of subdivisions the readiness of the equipment, documents, personnel for the Unit startup and obtaining a permit from CEP for the Unit changeover to the minimally-controlled level of power and to operation at energy levels of power with defining the maximum-permitted level of power, which is recorded in the “Log-book of technical directives” at the SSU workplace.

4) Issue to MCR the reactor core neutron-physics characteristics (at the first reaching MCL after the core refueling).

Bringing the reactor to the sub-critical state shall be performed only after evaluating the expected critical boric acid concentration.

Bringing the reactor to the sub-critical state after first loading shall be performed as per the «Program on Physical Startup».

At the reactor bringing to critical condition after refueling (fuel loading), set EP and PP setpoints by 20 sec and 40 sec period, respectively.

#### 4.2.4.2 CPS CR shall be taken up in the following sequence:

1) CPS CR groups No.1-9 shall be withdrawn from the core in group mode by-turns in their numbering sequence by 35 cm pitches (control impact is generated to CPS CR drives within not more than 18 sec) with the time delay between the pitches at least 60 sec at stable NFME readings.

2) Rod group No. 10 shall be taken up to 50-60 % height of the bottom position with the same sequence.

#### If in CPS CR lifting process the period of the neutron power increasing becomes less 60 sec as per the readings of at least one of NFME channels, immediately terminate lifting of the rod group and continue it only after increasing of the period up to infinity and detailed analysis of the situation caused this decreasing.

#### In case of violation of the logical sequence in transferring CPS CR groups movement, it is forbidden to reach MCL of power.

#### If CPS CR position indication is lost, terminate lifting of the rod group, reveal the reason of loss, eliminate malfunctioning and continue lifting the rod group.

#### 4.2.4.3 Bringing the reactor to MCL of power is performed by means of decreasing the boric acid concentration in the primary circuit coolant using the make-up and blow-down system. TC system shall be started and MBF anion-exchanger charging shall be started jointly with starting boric acid removal.

#### 4.2.4.4 Upon reaching the startup range, terminate water exchange for the time sufficient for balancing the boric acid concentration in the primary circuit, PRZ, make-up deaerator (difference of concentrations is not more than 0.5 g/dm3).

#### Sampling for BAS concentration control shall be performed at least once in 30 minutes additionally to the continuous monitoring.

#### 4.2.4.5 In startup interval, pure condensate flow-rate supplied to the primary circuit at startup after refueling (fuel loading) shall not be more than 6,5 t/h.

#### The procedure for defining the pure condensate flow-rate shall be agreed in the established manner and approved by the chief engineer.

#### It the approved procedure is not available, the permissible pure condensate flow-rate in the startup range is not more than 6,5 t/h.

#### 4.2.4.6 During approaching by the reactor to MCL of power, the following is forbidden:

1) To perform operations leading to the primary circuit coolant temperature and density variation.

2) To perform any repair activities at the CPS and the reactor NFME equipment and circuits.

In case of necessity to perform these activities, water-exchange shall be terminated.

3) Simultaneously perform any combination of the operations on CR CPS withdrawal from the reactor core, changing boric acid concentration in the primary circuit water and changing the primary circuit water temperature beyond the range (260÷280) °С.

4) Actuate or trip RCPS.

5) Remove boric acid from the primary circuit within the startup range at flow-rate more than the permitted value (item 4.2.4.5).

6) Drop pressure in SG.

7) Perform any other operations, which may lead to the unforeseen reactor core reactivity variation.

#### 4.2.4.7 Upon reaching the critical state, the period of increasing the reactor neutron power shall not be less than 60 sec.

#### 4.2.4.8 At MCL of power (10-5÷1) % Nnom after completion of Н3ВО3 removal from the primary circuit and BAS concentration balancing in the reactor, PRZ and the make-up deaerator, it is required to record the parameters of the reactor start-up condition.

#### 4.2.4.9 After reaching MCL of power, CR CPS adhesion with their drives shall be checked.

#### The check shall be performed by moving CR CPS down from the top position to the defined distance (within (35÷70) cm). Availability of adhesion shall be determined by changing of reactivity or neutron flux.

#### It is allowed to check CR CPS adhesion with their drives at the power level up to 40 % Nnom.

#### 4.2.4.10 Perform experimental determination of the neutron-physics characteristics of the core as per the program on experimental determination of the neutron-physics characteristics of the core during the Unit operation after first reaching the critical condition after refueling (fuel loading).

#### At the reactor power minimally possible for performing experiment, take measurement of emergency protection efficiency. Measurements of neutron-physical characteristics shall be performed after commissioning with refueling.

#### 4.2.4.11 Primary and secondary circuit water chemistry corresponds to the requirements of water chemistry norms specified in Appendix F.

**4.2.5 The reactor power buildup over the minimally-controlled level of power**

#### 4.2.5.1 In the process of the reactor power buildup, check transfer of all NFME channels to the operating range.

#### 4.2.5.2 Prepare FWP for startup.

#### Turn on FWP as per the OI.

#### 4.2.5.3 By measure of RP power increasing and feed water flow-rate to SG increasing, put the main feed water regulators into the automatic mode of operation, check covering up to 50 % and activation of the watching mode of the feed water startup regulators.

#### 4.2.5.4 Turn off the running EFWP.

#### 4.2.5.5 At the reactor power within the level of the Unit HL ((7÷12)% of Nnom), serviceability of all APC channels shall be checked by turns at the different control modes.

#### The check in the neutron power maintaining mode shall be performed by CPS CR displacement down to 35 cm distance in the individual control mode. After check completion restore the initial CR CPS position. The check in the secondary circuit pressure maintaining mode shall be performed by changing steam extraction.

#### 4.2.5.6 Upon reaching the reactor power value ((7÷12) % of Nnom), preliminary NFME calibration shall be performed by the results of the neutron power calculation made by the values of the heat engineering parameters.

#### 4.2.5.7 The reactor power buildup shall be performed in the manual mode at the rate corresponding to Table 3.2.1.6.1 in such a way that at decreasing the boric acid content in the primary circuit water, CR CPS of the operating group shall be constantly in position shown in figure Е.2 of Appendix E).

#### 4.2.5.8 In the process of the reactor power buildup and during further operation of the Unit the following requirements shall be fulfilled:

1) Control for RP equipment joints tightness shall be performed by the primary and secondary circuits.

2) Using the process radiation situation monitoring system (PRSMS), continuous control for fuel cladding leakiness shall be performed by the specific total gamma activity, neutron flux density.

3) Periodic control of the primary and secondary circuit media isotopic composition shall be performed by the methods of sample radiochemical analysis.

4) The control shall be provided for the radioactive gas releases to the Unit vent stack and radiochemical nuclides discharges with the liquid wastes, specific air activity control in the attended and unattended premises of the reactor compartment, the values of which shall not exceed the regulated vales and norms.

#### 4.2.5.9 The pressure in the turbine condenser shall be not more than 0,01 MPa. Six BRU-K are activated. Steam relief from the secondary circuit steam-lines is transferred to the turbine condenser.

#### Prior to the turbine startup, the reactor thermal power may be increased up to 40 % Nnom. Steam pressure in MSH shall be maintained by degree of BRU-K opening in the automatic mode.

#### 4.2.5.10 It is allowed to switch the turbine-generator on, if:

1) SG is fed from FWP;

2) EPCS is in operation;

3) steam pressure in MSH is equal to the nominal value;

4) total flow-rate of the main steam via BRU-K to the turbine condensers provides for taking the setting load;

5) APC is in «N» mode.

#### 4.2.5.11 Check correspondence of the pre-startup parameters to the requirements and record them to the operative log-book. Startup the turbine and ascend power as per OI for TG.

#### 4.2.5.12 Perform synchronization, switch on TG and continue load ascension.

#### 4.2.5.13 In all SG blow-down system operation modes, total flow-rate of blow-down water from all four SG shall amount not more than 75 t/hr at РSG=6,2 MPa.

Maximal blow-down water flow-rate by blow-down line from "salt" section of each steam-generator shall amount 18 t/h.

Maximal blow-down water flow-rate from united blow-down line of each SG shall amount 20 t/h.

**4.3 The Unit startup after hot standby**

#### 4.3.1 It is allowed to perform the Unit startup after shutdown with duration less than 3 days after:

1) Revealing the reason for shutdown and eliminating of failures or replacing the faulty equipment, set of devices, system elements.

During short-term shutdown of the Unit due to the mistakes of the personnel or protections activation, it is forbidden to make switchovers in the process and electric circuits, which may cause changing of these systems’ condition existed before shutdown, except for switchovers justified by the process necessity.

2) The reactor plant heat-up up to the nominal parameters after shutdown with cool down.

Conditions and sequence of activities on RP heat-up are described in section 4.2.2.

3) Fulfillment of the requirements to condition of the equipment and systems listed in item 4.1.4.

If during the Unit shutdown any repair activities have been performed at its systems and equipment, upon completion of the repair activities serviceability of these systems and equipment shall be checked.

4) The minimal scope of tests specified in section 10.2 shall be performed prior to reaching MCL of power.

5) Obtaining the permit for the Unit startup.

#### 4.3.2 Bringing RP to MCL of power and further power ascension up to Nnom after hot standby shall be performed in the sequence defined in items 4.2.4.2.÷4.2.5.12.

# 5 THE UNIT OPERATION AT THE ENERGY LEVELS OF POWER

**5.1 Safety Unit operation conditions at the energy levels of power**

#### 5.1.1 Section 5.1 contains safety Unit operation conditions at the energy levels of power in case of failures in the systems important to safety. The permissible time for the failed element withdrawal to repair is defined based on the relevant system backup and reliability degree as well as measures and actions of the personnel on safety assurance in conditions of this repair conductions are specified with indication of the permissible power level.

#### 5.1.2 In the process of the Unit operation serviceability of the systems and equipment shall be confirmed by periodic and unscheduled tests and checks (see section 10.2), if required The parameters of the equipment and systems at the normal operation conditions are listed in Table 3.2.1.1 and in Appendix В.

#### 5.1.3 In case of failures of individual types of the equipment with the potential danger of pre-emergency situation occurrence, it is required to reduce the reactor power up to the permitted value as per the Table 5.1.3.1.

Table 5.1.3.1 –Limits at the Unit being in the design conditions in case of failures and withdrawal of the equipment and systems for repair

Conditions: 1- operation at power; 2 –the reactor is at MCL of power; 3 –«hot»; 4 – «cold»; 5 –shutdown for repair; 6 –refueling

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **No.** | **Initial condition** | **Kind of trouble, malfunction, failure** | **Actions of the operative personnel** | **Fulfillment period** | **Final condition** | **Note** | |
| 1 | YA – the reactor coolant system | | | | | | |
| 1.1 | 1 | If there is:   1. boric solution on the separating bellows and RMJ studs are flooded  OR  1. leakage through the internal gasket of CPS drive flanged joints  OR 3) leakage through the external RMJ gasket | Changeover the Unit to condition 2 | 1 hour | 2 | | At the specified rate |
| 2 | If there is:   1. boric solution on the separating bellows and RMJ studs are flooded  OR  1. leakage through the internal gasket of CPS drive flanged joints  OR 3) leakage through the external RMJ gasket | Changeover the Unit to condition 3 | 6 hours | 3 | | At the specified rate |

| Table 5.1.3.1, continued | | | | | | | | | | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **No.** | **Initial condition** | **Kind of trouble, malfunction, failure** | **Actions of the operative personnel** | **Fulfillment period** | | | **Final condition** | | | **Note** | | | |
|  | 3 | If there is:  1) boric solution on the separating bellows and RMJ studs are flooded OR  1. leakage through the internal gasket of CPS drive flanged joints  OR 3) leakage through the external RMJ gasket | Changeover the Unit to condition 4 | 24 hours | | | 4 | | | At the specified rate | | | |
| 1.2 | 1 | Leakage through the internal RMJ gasket | To be in condition 1 AND Changeover the Unit to condition 2 | 24 hours  1 hour | | | 1  2 | | | At the specified rate | | | |
| 2 | Leakage through the internal RMJ gasket | Changeover the Unit to condition 3 | 6 hours | | | 3 | | | At the specified rate | | | |
| 3 | Leakage through the internal RMJ gasket | Changeover the Unit to condition 4 | 24 hours | | | 4 | | | At the specified rate | | | |
| 1.3 | 1 | There is the primary circuit leakage at flow-rate more than 0,1 t/hr but less than 2,0 t/hr defined using MCDS LMS, radiation monitoring system and APCS process control systems of the Unit | Changeover the Unit to condition 2. | 1 hour | | | 2 | | | Changeover the Unit to condition 2. | | | |
| 2 | There is the primary circuit leakage at flow-rate more than 0,1 t/hr but less than 2,0 t/hr defined using MCDS LMS, radiation monitoring system and APCS process control systems of the Unit | Changeover the Unit to condition 3. | 6 hours | | | 3 | | | Changeover the Unit to condition 3. | | | |
| 3 | There is the primary circuit leakage at flow-rate more than 0,1 t/hr but less than 2,0 t/hr defined using MCDS LMS, radiation monitoring system and APCS process control systems of the Unit | Changeover the Unit to condition 4. | 24 hours | | | 4 | | | Changeover the Unit to condition 4. | | | |
| 1.4 | 1 | Reaching the operational limit considering the sum of I131-I135, which equals to 3,7×107 Bq/kg (1×10-3 Ci/kg) | Order of actions:  - Decrease the RP power down to the value of (2-15)% Nnom;  - Decrease the rate of power rise and reactor power reduction, specifically:  1) Scheduled unloading down to 80%Nnomshall be performed with the maximum rate of 1%Nnom/min;  2) Power shall be increased with the maximum rate of:  а) from 50% Nnom to1%Nbom/min;  b) from 50% Nnom to80% Nnom- 5%Nnom/h;  c) from 80% Nnom to100% Nnom- 1%Nnom/h;  - the position of CPS CR regulation group shall beb maintained at the constant altitude. Maintaining of heat power shall be performed by changing of boric acid concentration in the primary circuit coolant by means of periodical water exchange process. | The RP operation time after violation of operational limits shall be defined depending on the radiation situation | | |  | | | In case it is impossible to decrease the activity of reference iodine radionuclides in the primary circuit coolant below the operational ionic limits. RP shall be shutdown and it is necessary to perform the cladding failure detection of fuel elements of all fuel loading assemblies. | | | |
| 1.5 | 1 | Occurrence of leakages through ICDS terminations | Changeover the Unit to condition 2 | 1 hour | | | 2 | | | At the specified rate | | | |
| 2 | Occurrence of leakages through ICDS terminations | Changeover the Unit to condition 3 | 6 hours | | | 3 | | | At the specified rate | | | |
| 3 | Occurrence of leakages through ICDS terminations | Changeover the Unit to condition 4 | 24 hours | | | 4 | | | At the specified rate | | | |
| 1.6 | 1 | Occurrence of leakages or steaming at the upper unit | Changeover the Unit to condition 2 | 1 hour | | | 2 | | | At the specified rate | | | |
| 2 | Occurrence of leakages or steaming at the upper unit | Changeover the Unit to condition 3 | 6 hours | | | 3 | | | At the specified rate | | | |
| 3 | Occurrence of leakages or steaming at the upper unit | Changeover the Unit to condition 4 | 24 hours | | | 4 | | | At the specified rate | | | |
| 1.7 | 1 | Occurrence of leakage in the pipelines, covered by LBB:  - MCP;  - connecting pipeline;  - ECCS pipeline.  LMS-H and/or ALMS have been registered (equipment and pipelines status indicator is flashing by «yellow color» at the main video-frame of TLSU monitor) | 1. Check the information on leakage availability presented at additional video-frames of TLSU monitor.  2. Upon leakage confirmation, changeover the Unit to condition 4. | 1 hour | | | 4 | | | At the specified rate | | | |
| 1.8 | 1 | Full failure of one of ALMS or LMS-H systems (failure of all system sensors providing leakage detection at one of 17 controlled pipelines or failure of the system SHWS) | 1. Take measures for the system functioning recovery.  2. If it is impossible to eliminate the failure within the specified time, changeover the Unit to condition 4. | 30 days | | | 4 | | | At the specified rate | | | |
| 1.9 | 1 | Failure of the second ALMS or LMS-H system (failure of all system sensors providing leakage detection at one of 17 controlled pipelines or failure of the system SHWS) within 30 days after failure of one of the system. | 1. Take measures for the system functioning recovery.  2. If it is impossible to eliminate the failure within the specified time, changeover the Unit to condition 4. | 1 hour | | | 4 | | | At the specified rate | | | |
| 2 | NFME | | | | | | | | | | | | | |
| 2.1 | 1 | Failure of one NFME channel within the operating range | Operation at the stabilized power level. Upon time expiration, changeover to condition 3 | 8 hours | | | 3 | | | | | At the specified rate | | | |
| 2.2 | 1 | Failure of two or more channels of one NFME set within the operating range | Emergency shutdown by EP button | Immediately | | | 3 | | | | |  | | | |
| 2.3 | 2 | Failure of one NFME channel in the startup range or in the source range | Power stabilizing at the level not more than 10-2 % Nnom. Upon expiration of time, changeover to condition 3 | 8 hours | | | 3 | | | | | Changeover to condition 3 shall be performed by boron injection up to the steady concentration | | | |
| 2.4 | 2 | Failure of two or more channels of one NFME set | Emergency shutdown by EP button | Immediately | | | 3 | | | | |  | | | |
| Failure of NFME source range channel includes uncertainty of measurement at source range chamber position beyond the maximal sensitivity zone (at the reactor power less than 10-6 Nnom). | | | | | | | | | | | | | | |
| 2.5 | 6 | Failure of two or more MSR channels | Refueling termination | Immediately | | | 6 | | | | |  | | | |
| 3 | **APC** | | | | | | | | | | | | | |
| 3.1 | 1 | Failure of one of two APC sets | Changeover to the second set.If the defect has not been eliminated. Discharge to power level of 0,9N add. | Immediately  8 hours | | | | | 1 |  | | | |
| 3.2 | 1 | Failure of both APC sets | Reduce the reactor power at a level of 0,9Nperm | Immediately | | | | | 1 | At the specified rate (Nperm – ROM setpoint) | | | |
| 4 | **EP – emergency protection of the reactor** | | | | | | | | | | | | | |
| 4.1 | 1 | Availability of malfunction in any of EP channels | Operation at the stabilized power level. (It is allowed to reduce the reactor power).  Upon expiration of time, changeover to condition 3 | 8 hours | | | 3 | | | At the specified rate | | | |
| 4.2 | 1 | Availability of malfunction in two different EP channels | Emergency shutdown by EP button | Immediately | | | 3 | | |  | | | |
| 4.3 | 1 | Availability of malfunction in more than two different EP channels | Emergency shutdown by EP button | Immediately | | | 3 | | |  | | | |
| 4.4 | 1 | Failure of two and more EP channels | Emergency shutdown by EP button | Immediately | | | 3 | | |  | | | |
| 4.5 | 1 | Failure of two alarm sets at MCR | Operation at the stabilized power level. Upon expiration of time, changeover to condition 3 | 24 hours | | | 3 | | | At the specified rate | | | |
| 4.6 | 1 | Failure of one set of EP executive part | Operation at the stabilized power level. Upon expiration of time, changeover to condition 3 | 8 hours | | | 3 | | | At the specified rate | | | |
| 4.7 | 1 | Failure of two sets of EP executive part | Emergency shutdown by EP button | Immediately | | | 3 | | |  | | | |
| 4.8 | 2 | Availability of malfunction in any one of EP channels | Operation at the stabilized power level. (Reactor power reducing is allowed).  Upon expiration of time, changeover to condition 3 | 8 hours | | | 3 | | | At the specified rate | | | |
| 4.9 | 2 | Availability of malfunction in two different EP channels of one set | Emergency reactor shutdown by button of manual emergency reactor shutdown | Immediately | | | 3 | | |  | | | |
| 4.10 | 2 | Availability of malfunction in two different EP channels of different sets | Emergency shutdown by EP button | Immediately | | | 3 | | |  | | | |
| 4.11 | 2 | Failure of one EP channel | Trip faulty cabinet (EP PPPE, EP LSPE, SHWC-P, IAPS).  Elimination of failure | 8 hours | | | 3 | | | At non-fulfillment within the defined time, changeover to mode 3 at the operating rate | | | |
| 4.12 | 2 | Failure of two and more EP channels | Emergency shutdown by EP button | Immediately | | | 3 | | |  | | | |
| 4.13 | 2 | Failure of two alarm sets at MCR | The reactor power stabilizing at the level not more than 10-2 % Nnom.  Elimination of failure | 24 hours | | | 2 | | | Upon expiration of time injection of boron with the steady concentration until the defect is eliminated | | | |
| 4.14 | 2 | Failure of one set of EP executive part | Bring the reactor to the power level not more than 10-2 % Nnom.  Elimination of failure | 8 hours | | | 2 | | | Upon expiration of time scheduled shutdown to condition 3 until the defect is eliminated | | | |
| 4.15 | 2 | Failure of two sets of EP executive part | Emergency shutdown by EP button  In case of EP button failure, changeover the reactor to hot standby by pressing button PP – 1. | Until the defect is eliminated | | | 3 | | |  | | | |
| 5 | **PP – preventive protection of the reactor** | | | | | | | | | | | | | |
| 5.1 | 1 | Malfunction of one PP channel | Operation at the stabilized power level. (It is allowed to reduce the reactor power). Upon expiration of time, reducing up to 40% Nnom | 168 hours | | | 1 | | | Upon expiration of time unloading by PP1 key up to the power level 40% Nnom | | | |
| 5.2 | 1 | Malfunction of two and more PP channels | Reduce power level to 40 % Nnom. Upon expiration of time changeover to condition 3 | 24 hours | | | 3 | | | At the specified rate | | | |
| 5.3 | 1 | Failure of one set of PP executive part | Operation at the stabilized power level. (It is allowed to reduce the reactor power). Upon expiration of time changeover to condition 3 | 8 hours | | | 3 | | | At the specified rate | | | |
| 5.4 | 1 | Failure of two sets of PP executive part | Unloading by PP1 key up to power level 40% Nnom. Upon expiration of time changeover to condition 3 | 8 hours | | | 3 | | | At the specified rate | | | |
| 5.5 | 2 | Malfunction of one PP channel | Power stabilizing at the level not more than 10-2% Nnom.  Upon expiration of time changeover to condition 3 | 168 hours | | | 3 | | | Changeover to condition 3 shall be performed by boron injection up to the steady concentration | | | |
| 5.6 | 2 | Malfunction of two PP channels | Power stabilizing at the level not more than 10-2% Nnom.  Upon expiration of time, changeover to condition 3  (if the failure occurred in the process of startup operations, changeover the plant to condition 3 immediately) | 24 hours | | | 3 | | | Changeover to condition 3 shall be performed by boron injection up to the steady concentration | | | |
| 5.7 | 2 | Malfunction of two and more PP channels | Power stabilizing at the level not more than 10-2% Nnom | 24 hours | | | 3 | | | At the specified rate | | | |
| 5.8 | ROM – reactor power limiter | | | | | | | | | | | | | |
| 5.8.1 | 1 | One ROM channel is in one set and/or one ROM channel is in another set is not in the operating condition | Restore operability of the channel | Before eliminating of the defect | | | 1 | | |  | | | |
|  | 1 | Failure of one ROM set | Restore the operability of the set.  After a period of time, decrease to 40% Nnom until the operability is restored. | 72 hours | | | 1  Not more than 40% Nnom | | | At the specified rate | | | |
|  | 1 | Failure of two ROM sets | Restore the operability of the set.  After a period of time, decrease to 40% Nnom until the operability is restored. | 8 hours | | | 1  Not more then 40% Nnom | | | After a period of time, unloading by using the switch PP1 to the power level of 40% Nnom | | | |
| 6 | **APP – accelerated preventive protection** | | | | | | | | | | | | | |
| 6.1 | 1 | Failure of APP executive part | Reducing the reactor power up to 70% Nnom | Immediately | | | 1 | | | At the specified rate | | | |
| 7 | **System of the reactor CPS group and individual control** | | | | | | | | | | | | | |
| 7.1 | 1 | Mismatching of CPS CR operating group to more than 60 mm | Restore CR position within the permissible limits OR Reduce the reactor power to 90% Nnom | 8 hours  Until the failure is eliminated | | | 1 | | | At the specified rate | | | |
| 7.2 | 1 | Violation of the design sequence of CPS CR groups movement:  1) individual CPS CR are moving up not with their group;  2) absence of the automatic movement transfer between CPS CR groups;  3) simultaneous movement of two groups if they are higher than 50% from the bottom of the core | Changeover the unit to condition 3 | Immediately | | | 3 | | | Emergency shutdown by EP button | | | |
|  | 2 | Violation of the design sequence of CPS CR groups movement:  1) individual CPS CR are moving up not with their group;  2) absence of the automatic movement transfer between CPS CR groups;  3) simultaneous movement of two groups in case they are higher than 50% from the bottom of the core | Changeover the unit to condition 3 | Immediately | | | 3 | | | Emergency shutdown by EP button | | | |
| 7.3 | 1 | Spontaneous nonstop movement upward of any CPS CR or a group | Changeover the unit to condition 3 | Immediately | | | 3 | | | Emergency shutdown by EP button | | | |
| 7.4 | 1 | Drop of one CPS CR to LSS | Reduce the reactor power to 90% Nnom | Immediately | | | 1 | | | At the specified rate | | | |
| 7.5 | 1 | Drop of two and more CPS CR to LSS | Changeover the unit to condition 3 AND Eliminate the failure OR Changeover the unit to condition 4 | Immediately  8 hours | | | 3 and 4 | | | Emergency shutdown by EP button | | | |
| 2 | Drop of two and more CPS CR to LSS | Changeover the unit to condition 3 AND Eliminate the failure OR Changeover the unit to condition 4 | Immediately  8 hours | | | 4 | | | Emergency shutdown by EP button | | | |
| 7.6 | 1 | There is no control for position of one CPS CR of the operating group (no CR position indication at MCR) | Trip APC AND Unload reactor up to power 90% ofNnom AND Changeover the unit to condition 3 AND Eliminate the failure OR Changeover the unit to condition 4 | Immediately  8 hours  8 hours  Until the failure is eliminated | | | 3 and 4 | | | At the specified rate | | | |
|  | 2 | There is no control for position of one CPS CR of the operating group (no CR position indication at MCR) | Eliminate the failure OR Changeover the unit to condition 3 AND Eliminate the failure OR Changeover the unit to condition 4 | 8 hours  8 hours  Until the failure is eliminated | | | 3 and 4 | | | At the specified rate | | | |
| 7.7 | 1 | There is no control for position of two CPS CR of the operating group (no CR position indication at MCR) | Trip APC AND Unload reactor up to power 0,9Nnom AND Eliminate the failure OR Changeover the unit to condition 3 AND Eliminate the failure OR Changeover the unit to condition 4 | Immediately  8 hours  8 hours  Until the failure is eliminated | | | 3 and 4 | | | At the specified rate  At the specified rate | | | |
| 2 | There is no control for position of two CPS CR (no CR position indication at MCR) | Eliminate the failure OR Changeover the unit to condition 3 AND Eliminate the failure OR Changeover the unit to condition 4 | 8 hours  8 hours  Until the failure is eliminated | | | 3 and 4 | | | At the specified rate | | | |
| 7.8 | 1 | There is no control for position of more than two CPS CR (no CR position indication at MCR) | Changeover the unit to condition 3 AND Eliminate the failure OR Changeover the unit to condition 4 | Immediately  8 hours  Until the failure is eliminated | | | 3 and 4 | | | At the specified rate | | | |
| 2 | There is no control for position of more than two CPS CR (no CR position indication at MCR) | Changeover the unit to condition 3 AND Eliminate the failure OR Changeover the unit to condition 4 | Immediately  8 hours  Until the failure is eliminated | | | 3  4 | | | At the specified rate | | | |
| 7.9 | 1 | One CPS CR is not controlled by CK | Eliminate the failure OR Reduce the reactor power to 90% Nnom | 3 hours  Until the failure is eliminated | | | 1 | | | At the specified rate | | | |
| 7.10 | 1 | Two and more CPS CR are not controlled by CK | Changeover the unit to condition 3 AND Eliminate the failure OR Changeover the unit to condition 4 | Immediately  8 hours  Until the failure is eliminated | | | 3 and 4 | | | At the specified rate | | | |
| 2 | Two and more CPS CR are not controlled by CK | Changeover the unit to condition 3 AND Eliminate the failure OR Changeover the unit to condition 4 | Immediately  8 hours  Until the failure is eliminated | | | 3 and 4 | | | At the specified rate | | | |
| 7.11 | 1 | Hang up of one CPS CR at the height more than 100 cm from the core bottom | Changeover the unit to condition 3 AND Eliminate the failure OR Changeover the unit to condition 4 | Immediately  8 hours  Until the failure is eliminated | | | 4 | | | At the specified rate | | | |
| 7.12 | 2 | Hang up of one CPS CR at the height less than 100 cm from the core bottom | Trip APC AND Reduce the reactor power to 90% Nnom | Immediately  Until the failure is eliminated | | | 1 | | | At the specified rate | | | |
| 7.13 | 1 | Hang up of one CPS CR at the height less than 100 cm from the core bottom and position indication of the other CPS CR is lost | Changeover the unit to condition 3 AND Eliminate the failure OR Changeover the unit to condition 4 | Immediately  8 hours  Until the failure is eliminated | | | 4 | | | At the specified rate | | | |
|  | 2 | Hang up of one CPS CR at the height less than 100 cm from the core bottom and position indication of the other CPS CR is lost | Changeover the unit to condition 3 AND Eliminate the failure OR Changeover the unit to condition 4 | Immediately  8 hours  Until the failure is eliminated | | | 4 | | | At the specified rate | | | |
| 7.14 | 1 | Hang up of two and more CPS CR at the height less than 100 cm from the core bottom | Changeover the unit to condition 3 AND Eliminate the failure OR Changeover the unit to condition 4 | Immediately  8 hours  Until the failure is eliminated | | | 4 | | | At the specified rate | | | |
| 2 | Hang up of two and more CPS CR at the height less than 100 cm from the core bottom | Changeover the unit to condition 3 AND Eliminate the failure OR Changeover the unit to condition 4 | Immediately  8 hours  Until the failure is eliminated | | | 4 | | | At the specified rate | | | |
| 7.15 | 1 | Drop of one CPS CR from the group used for APP and hang up at the height less than 100 cm from the core bottom | Eliminate the failure OR Changeover the unit to condition 3 AND Eliminate the failure OR Changeover the unit to condition 4 | 8 hours  8 hours  Until the failure is eliminated | | | 4 | | | At the specified rate | | | |
|  | 2 | Drop of one CPS CR from the group used for APP and hang up at the height less than 100 cm from the core bottom | Eliminate the failure OR Changeover the unit to condition 3 AND Eliminate the failure OR Changeover the unit to condition 4 | 8 hours  8 hours  Until the failure is eliminated | | | 3 and 4 | | | At the specified rate | | | |
| 7.16 | 1 | Hang up of one CPS CR from the group used for APP at the height less than 100 cm from the core bottom (at APP activation) | Reduce the reactor power to 40% Nnom AND Eliminate the failure OR Changeover the unit to condition 3 AND Eliminate the failure OR Changeover the unit to condition 4 | Immediately  8 hours  8 hours  Until the failure is eliminated | | | 3 and 4 | | | At the specified rate  At the specified rate | | | |
| 7.17 | 1,2 | Any of emergency protection groups (No. 1÷7), except for APP group is in the core | Changeover the Unit to condition 3 | 15 min | | | 3 | | | Changeover to condition 3 shall be performed by boron injection till steady state concentration | | | |
| 7.18 | 1 | At APP signal receiving, APP group CPS CR drops | Extract APP group CPS CR to ULLS  CPS CR of APP group may be lifted to ULS only when the reason for APP signal generation was revealed and eliminated.  OR  Changeover the Unit to condition 3 | not more than 3 h.  Immediately | | | 1  3 | | | Changeover shall be performed by boron injection | | | |
| 8 | Pressurizing system - YP | | | | | | | | | | | | | |
| 8.1 | 1 OR 2 OR 3 | Malfunction of one pulse valve of any PRZ PSD | To be in the initial condition AND Eliminate the defect | After first reaching condition 4 | | | 4 | | |  | | | |
| 8.2 | 1 | Malfunction of the main valve of one PRZ PSD  OR  Malfunction of two pulse valves of one PRZ PSD | Reduce the reactor power to 50% Nnom  AND  To be in condition 1 until the failure is eliminated  AND  Changeover the unit to condition 2  AND  Changeover the unit to condition 3  AND  Changeover the unit to condition 4 | 1 hour  24 hours  1 hour  6 hours  24 hours | | | 1  1  2  3  4 | | | At the specified rate  At the specified rate  At the specified rate | | | |
| 2 | Malfunction of the main valve of one PRZ PSD  OR  Malfunction of two pulse valves of one PRZ PSD | Changeover the unit to condition 3  AND  Changeover the unit to condition 4 | 6 hours  24 hours | | | 3  4 | | | At the specified rate  At the specified rate | | | |
| 3 | Malfunction of the main valve of one PRZ PSD  OR  Malfunction of two pulse valves of one PRZ PSD | Changeover the unit to condition 4 | 24 hours | | | 4 | | | At the specified rate | | | |
| 8.3 | 1 | Malfunction of two and more PRZ PSD | Changeover the unit to condition 2  AND  Changeover the unit to condition 3  AND  Changeover the unit to condition 4 | 1 hour  6 hours  24 hours | | | 2  3  4 | | | At the specified rate  At the specified rate  At the specified rate | | | |
|  | 2 | Malfunction of two and more PRZ PSD | Changeover the unit to condition 3  AND  Changeover the unit to condition 4 | 6 hours  24 hours | | | 3  4 | | | At the specified rate  At the specified rate | | | |
| 3 | Malfunction of two and more PRZ PSD | Changeover the unit to condition 4 | 24 hours | | | 4 | | | At the specified rate | | | |
| 8.4 | 1 | Malfunction of both injection lines in PRZ YP11,12 | Changeover the unit to condition 2  AND  Changeover the unit to condition 3  AND  Changeover the unit to condition 4 | 1 hour  6 hours  24 hours | | | 2  3  4 | | | At the specified rate  At the scheduled At the specified rate | | | |
|  | 2 | Malfunction of both injection lines in PRZ YP11,12 | Changeover the unit to condition 3  AND  Changeover the unit to condition 4 | 6 hours  24 hours | | | 3  4 | | | At the specified rate  At the specified rate | | | |
|  | 3 | Malfunction of both injection lines in PRZ YP11,12 | Changeover the unit to condition 4 | 24 hours | | | 4 | | | At the specified rate | | | |
| 8.5 | 1 | Malfunction of line YP13 with injection control valve  AND/OR  Malfunction of one PRZ injection line YP11(12) | Reduce the reactor power to 40% Nnom until the failure is eliminated  AND  Changeover the Unit to condition 2  AND  Changeover the Unit to condition 3  AND  Changeover the Unit to condition 4 | 1 hour  1 hour  6 hours  24 hours | | | 1  2  3  4 | | | At the specified rate  At the specified rate  At the specified rate  At the specified rate | | | |
|  | 2 | Malfunction of line YP13 with injection control valve  AND/OR  Malfunction of one PRZ injection line YP11(12) | Changeover the Unit to condition 3  AND  Changeover the Unit to condition 4 | 6 hours  24 hours | | | 3  4 | | | At the specified rate  At the specified rate | | | |
|  | 3 | Malfunction of line YP13 with injection control valve  AND/OR  Malfunction of one PRZ injection line YP11(12) | Changeover the Unit to condition 4 | 24 hours | | | 4 | | | At the specified rate | | | |
| 8.6 | 1 OR 2 OR 3 | Tightness failure of the PRZ manhole internal gasket | To be in the initial condition | Until first withdrawal for SPM | | | Current | | |  | | | |
| 8.7 | 1 | Leakage through both gaskets of PRZ manhole and PRZ TEH | Changeover the Unit to condition 2  AND  Changeover the Unit to condition 3  AND  Changeover the Unit to condition 4 | 1 hour  6 hours  24 hours | | | 2  3  4 | | | At the specified rate  At the specified rate  At the specified rate | | | |
|  | 2 | Leakage through both gaskets of PRZ manhole and PRZ TEH | Changeover the Unit to condition 3  AND  Changeover the Unit to condition 4 | 6 hours  24 hours | | | 3  4 | | | At the specified rate  At the specified rate | | | |
|  | 3 | Leakage through both gaskets of PRZ manhole and PRZ TEH | Changeover the Unit to condition 4 | 24 hours | | |  | | | At the specified rate | | | |
| 9 | YB10,20,30,40W001 – steam-generators | | | | | | | | | | | | | |
| 9.1 | 1 | Tightness failure of one (first or second) gasket of the primary circuit SG header flanged connection | Stay in condition 1  AND  Changeover the Unit to condition 2  AND  Changeover the Unit to condition 3  AND  Changeover the Unit to condition 4 | 72 hours  1 hour  6 hours  24 hours | | | 1  2  3  4 | | | Open the drainage from the control line  At the specified rate  At the specified rate  At the specified rate | | | |
| 2 | Tightness failure of one (first or second) gasket of the primary circuit SG header flanged connection | Changeover the Unit to condition 3  AND  Changeover the Unit to condition 4 | 6 hours  24 hours | | | 3  4 | | | At the specified rate  At the specified rate | | | |
| 3 | Tightness failure of one (first or second) gasket of the primary circuit SG header flanged connection | Changeover the Unit to condition 4 | 24 hours | | | 4 | | | At the specified rate | | | |
| 9.2 | 1 | Leakage through both gaskets of the primary circuit SG header | Changeover the Unit to condition 2  AND  Changeover the Unit to condition 3  AND  Changeover the Unit to condition 4 | 1 hour  6 hours  24 hours | | | 2  3  4 | | | At the specified rate  At the specified rate  At the specified rate | | | |
| 2 | Leakage through both gaskets of the primary circuit SG header | Changeover the Unit to condition 3  AND  Changeover the Unit to condition 4 | 6 hours  24 hours | | | 3  4 | | | At the specified rate  At the specified rate | | | |
| 3 | Leakage through both gaskets of the primary circuit SG header | Changeover the Unit to condition 4 | 24 hours | | | 4 | | | At the specified rate | | | |
| 9.3 | 1 OR 2 OR 3 | Tightness failure of the secondary circuit SG header internal gasket | To be in the initial condition | Until the first withdrawal to SPM | | | Current | | | Close the drainage from the control line | | | |
| 9.4 | 1 | Leakage through both gaskets of the secondary circuit SG header | To be in condition 1  AND  Changeover the Unit to condition 2  AND  Changeover the Unit to condition 3  AND  Changeover the Unit to condition 4 | 72 hours  1 hour  6 hours  24 hours | | | 1  2  3  4 | | | At the specified rate  At the specified rate  At the specified rate | | | |
| 2 | Leakage through both gaskets of the secondary circuit SG header | Changeover the Unit to condition 3  AND  Changeover the Unit to condition 4 | 6 hours  24 hours | | | 3  4 | | | At the specified rate  At the specified rate | | | |
| 3 | Leakage through both gaskets of the secondary circuit SG header | Changeover the Unit to condition 4 | 24 hours | | | 4 | | | At the specified rate | | | |
| 9.5 | 1 OR 2 OR 3 | Tightness failure of the SG manhole internal gasket | To be in the initial condition | Until the first withdrawal to preventive maintenance | | | Current | | |  | | | |
| 9.6 | 1 | Leakage through both gaskets of the SG manhole | To be in condition 1  AND  Changeover the Unit to condition 2  AND  Changeover the Unit to condition 3  AND  Changeover the Unit to condition 4 | 72 hours  1 hour  6 hours  24 hours | | | 1  2  3  4 | | | At the specified rate  At the specified rate  At the specified rate | | | |
| 2 | Leakage through both gaskets of the SG manhole | Changeover the Unit to condition 3  AND  Changeover the Unit to condition 4 | 6 hours  24 hours | | | 3  4 | | | At the specified rate  At the specified rate | | | |
| 3 | Leakage through both gaskets of the SG manhole | Changeover the Unit to condition 4 | 24 hours | | | 4 | | | At the specified rate | | | |
| 9.7 | 1 | Primary circuit coolant leakage to the secondary circuit via individual SG is more than 4 kg/hr  OR  Permissible value of iodine-131 radionuclide specific activity in blow-down water of each SG is more than 370 Bq/kg (1×10-8 Cu/kg)  OR  Discontinuous variation of the a.m. values in comparison with the previous measurement | To be in condition 1  AND  Upon confirmation of malfunctions, changeover the Unit to condition 2  AND  Changeover the Unit to condition 3  AND  Changeover the Unit to condition 4 | 2-3 hours  1 hour  6 hours  24 hours | | | 1  2  3  4 | | | Perform at least 2 repeated measurements of the specified values  At the specified rate  At the specified rate  At the specified rate | | | |
| 2 | Primary circuit coolant leakage to the secondary circuit via individual SG is more than 4 kg/hr  OR  Permissible value of iodine-131 radionuclide specific activity in blow-down water of each SG is more than 370 Bq/kg (1×10-8 Cu/kg)  OR  Discontinuous variation of the a.m. values in comparison with the previous measurement | Changeover the Unit to condition 3  AND  Changeover the Unit to condition 4 | 6 hours  24 hours | | | 3  4 | | | At the specified rate  At the specified rate | | | |
|  | 3 | Primary circuit coolant leakage to the secondary circuit via individual SG is more than 4 kg/hr  OR  Permissible value of iodine-131 radionuclide specific activity in blow-down water of each SG is more than 370 Bq/kg (1×10-8 Cu/kg)  OR  Discontinuous variation of the a.m. values in comparison with the previous measurement | Changeover the Unit to condition 4 | 24 hours | | | 4 | | | At the specified rate | | | |
| 1 OR 2 OR 3 | Primary circuit coolant leakage to the secondary circuit is more than 5 kg/hr  AND  Discontinuous variation of leakages | Changeover the Unit to condition 3  AND  Changeover the Unit to condition 4 | Immediately  24 hours | | | 3  4 | | | Emergency shutdown by EP key  At the specified rate | | | |
| 10 | RA – system of the main SG steam-lines | | | | | | | | | | | | | |
| 10.1 | 1 | One SG SV on the loop with running RCPS is inadvertently opened | Reduce the reactor power to 67% Nnom power | 1 hour | | | 1  Until the defect is eliminated | | | At the specified rate | | | |
| 10.2 | 1 | Both SG SV of any SG are inadvertently opened | Changeover the Unit to condition 2  AND  Changeover the Unit to condition 3  AND  Changeover the Unit to condition 4 | 1 hour  6 hours  24 hours | | | 2  3  4 | | | At the specified rate  At the specified rate  At the specified rate | | | |
|  | 2 | Both SG SV of any SG failed | Changeover the Unit to condition 3  AND  Changeover the Unit to condition 4 | 6 hours  24 hours | | | 3  4 | | | At the specified rate  At the specified rate | | | |
| 3 | Both SG SV of any SG failed | Changeover the Unit to condition 4 | 24 hours | | | 4 | | | At the specified rate | | | |
| 10.3 | 1 | One BRU-A failed (regarding the mechanical part or non-redundant control devices) | To be in condition 1  AND  Changeover the Unit to condition 2  AND  Changeover the Unit to condition 3 | 72 hours  1 hour  6 hours | | | 1  2  3 | | | It is allowed not to check the other 3 BRU-A  At the specified rate  At the specified rate | | | |
| 2 | One BRU-A failed (regarding the mechanical part or non-redundant control devices) | Changeover the Unit to condition 3 | 6 hours | | | 3 | | | At the specified rate | | | |
| 10.4 | 1 | Any two BRU-A failed | Changeover the Unit to condition 2  AND  Changeover the Unit to condition 3 | 1 hour  6 hours | | | 2  3 | | | At the specified rate  At the specified rate | | | |
| 2 | Any two BRU-A failed | Changeover the Unit to condition 3 | 6 hours | | | 3 | | | At the specified rate | | | |
| 10.5 | 1 | One SG SV and BRU-A at one SG failed | Changeover the Unit to condition 2  AND  Changeover the Unit to condition 3  AND  Changeover the Unit to condition 4 | 1 hour  6 hours  24 hours | | | 2  3  4 | | | At the specified rate  At the specified rate  At the specified rate | | | |
| 2 | One SG SV and BRU-A at one SG failed | Changeover the Unit to condition 3  AND  Changeover the Unit to condition 4 | 6 hours  24 hours | | | 3  4 | | | At the specified rate  At the specified rate | | | |
| 3 | One SG SV and BRU-A at one SG failed | Changeover the Unit to condition 4 | 24 hours | | | 4 | | | At the specified rate | | | |
| 10.6 | 1 | One MSIV failed | To be in condition 1, after load decreasing, close valves RA10(20,30,40)S008 of faulty MSIV | Until the fauilure is eliminated | | | 1 | | | Trip RCPS, loops with failed MSIV. Close MSIV and eliminate possibility of its opening | | | |
| 10.7 | 1 | Two or more MSIV failed | Changeover the Unit to condition 2, close valves RA10(20,30,40)S008 of faulty MSIV  AND  Changeover the Unit to condition 3  AND  Changeover the Unit to condition 4 | 1 hour  6 hours  24 hours | | | 2  3  4 | | | At the specified rate  At the specified rate  At the specified rate | | | |
| 2 | Two or more MSIV failed | Changeover the Unit to condition 3  AND  Changeover the Unit to condition 4 | 6 hours  24 hours | | | 3  4 | | | At the specified rate  At the specified rate | | | |
| 3 | Two or more MSIV failed | Changeover the Unit to condition 4 | 24 hours | | | 4 | | | At the specified rate | | | |
| 10.8 | 1 | One MSIV failed and it is impossible to close it | Changeover the Unit to condition 2, close valves RA10(20,30,40)S008 of faulty MSIV  AND  Changeover the Unit to condition 3  AND  Changeover the Unit to condition 4 | 1 hour  6 hours  36 hours | | | 2  3  4 | | | At the specified rate  At the specified rate  At the specified rate | | | |
| 2 | One MSIV failed and it is impossible to close it | Close valves RA10(20,30,40)S008 of faulty MSIV. Changeover the Unit to condition 3  AND  Transfer the Unit to condition 4 | 6 hours  36 hours | | | 3  4 | | | At the specified rate  At the specified rate | | | |
| 3 | One MSIV failed and it is impossible to close it | Close valves RA10(20,30,40)S008 of faulty MSIV. Changeover the Unit to condition 4 | 24 hours | | | 4 | | | At the specified rate | | | |
| 11 | RZ – SG blow-down system | | | | | | | | | | | | | |
| 11.1 | 1 | Termination of at least one SG blow-down due to the blow-down system malfunctioning | To be in condition 1  AND  Changeover the Unit to condition 2  AND  Changeover the Unit to condition 3  AND  Changeover the Unit to condition 4 | 8 hours  1 hour  6 hours  24 hours | | | 1  2  3  4 | | | Eliminate the failure  At the specified rate  At the specified rate  At the specified rate | | | |
| 2 | Termination of at least one SG blow-down due to the blow-down system malfunctioning | Changeover the Unit to condition 3  AND  Changeover the Unit to condition 4 | 6 hours  24 | | | 3  4 | | | At the specified rate  At the specified rate | | | |
| 3 | Termination of at least one SG blow-down due to the blow-down system malfunctioning | Changeover the Unit to condition 4 | 24 | | | 4 | | | At the specified rate | | | |
| 11.2 | 1 | Deviation of one or several rated SG blow-down water quality indices | As per the Appendix F |  | | |  | | |  | | | |
|  | Violation of water chemistry of the primary and secondary circuits and violations in the systems of assurance and maintaining water chemistry of the primary and secondary circuits | | | | | | | | | | | | | |
| 12.1 | 1 | Deviation of one or several normalizing media quality indices of the primary and secondary circuits from water chemistry norms and also malfunctions in the systems supporting and maintaining water chemistry causing these deviations | In compliance with Appendix F |  | | | | |  |  | | | |
| 13 | YD10,20,30,40D001 – the reactor coolant pump set | | | | | | | | | | | | | |
| 13.1 | 1 | Malfunction of one of four running RCPS, which requires its shutdown as per OI RCPS | Reduce the reactor power to 67% Nnom, trip failed RCPS | Immediately | | | | 1 | | At the specified rate | | | |
| 13.2 | 1 | Malfunction of one of 3 running RCPS, which requires its shutdown as per OI RCPS | Reduce the reactor power to the permitted level as per item 1 of table 3.2.1.1.1, trip failed RCPS | Immediately | | | | 1 | | At the specified rate | | | |
| 13.3 | 1 | Malfunction of one of 2 running RCPS, which requires its shutdown as per OI RCPS | Changeover the Unit to condition 3 | Immediately | | | | 3 | | Emergency shutdown by EP key | | | |
| 13.4 | 1 | Termination of intermediate circuit water supply to RCPS | Monitor reactor power reducing to 67 % Nnom by fact of RCPS trip | 3 min | | | | 1 | | At the specified rate | | | |
| 2 OR 3 OR 4 | Termination of intermediate circuit water supply to RCPS | Check RCPS trip. Operation at power with incomplete number of loops is allowed. |  | | | | 2 (3,4) | |  | | | |
| 1 | Termination of intermediate circuit water supply to all RCPS | Changeover the Unit to condition 3  AND  Changeover the Unit to condition 4 | Immediately  24 hours | | | | 3  4 | | Emergency shutdown by EP key  At the specified rate | | | |
| 13.5 | 1 | Occurrence of graphite in water sample taken from RCPS off-line circuit | Reduce the reactor power to 67% Nnom, trip failed RCPS | Until the defect is eliminated | | | | 1 | | At the specified rate | | | |
| 2 OR 3 OR 4 | Occurrence of graphite in water sample taken from RCPS off-line circuit | Trip RCPS, stay in initial condition |  | | | | 2 (3,4) | |  | | | |
| 13.6 | 1 | Oil leakage from RCPS oil system | Reduce the reactor power to 67% Nnom, trip failed RCPS | Until the defect is eliminated | | | | 1 | | At the specified rate | | | |
| 13.7 | 2 OR 3 OR 4 | Oil leakage from RCPS oil system | Trip RCPS. Changeover the Unit to mode 5 for repair | Until the defect is eliminated | | | | 2 (3,4) | |  | | | |
| 13.8 | 1 | Off-line circuit water temperature increasing over 150 оС | Reduce the reactor power to 67% Nnom, trip failed RCPS | Until the defect is eliminated | | | | 1 | | Perform RCPS inspection | | | |
| 2 OR 3 OR 4 | Off-line circuit water temperature increasing over 150 оС | Trip RCPS. Changeover the Unit to mode 5 for repair |  | | | | 2 (3,4) | | Perform RCPS inspection | | | |
| 14 | Emergency core cooling system YT (passive part – 1st stage ECCS HA) | | | | | | | | | | | | | |
| 14.1 | 1 | Tightness failure of ECCS HA manhole internal gasket | To be in condition 1  AND  Changeover the Unit to condition 2  AND  Changeover the Unit to condition 3  AND  Changeover the Unit to condition 4 | 0,5 hour  1 hour  6 hours  24 hours | | | | 1  2  3  4 | | | Clarify situation  At the specified rate  At the specified rate  At the specified rate | | | |
| 14.2 | 1 | Leakage from ECCS HA due to which it is impossible to maintain the nominal level, pressure or boric acid concentration decreasing in ECCS HA  OR  Leakage of both ECCS HA manhole gaskets  OR  Both ECCS HA SV failed  OR  At least one of FSGV or interlocks activating their closing failed | To be in condition 1  AND  Changeover the Unit to condition 2  AND  Changeover the Unit to condition 3  AND  Changeover the Unit to condition 4 | 0,5 hour  1 hour  6 hours  24 hours | | | | 1  2  3  4 | | | Clarify the situation  At the specified rate  At the specified rate  At the specified rate | | | |
|  | 2 | Leakage from ECCS HA due to which it is impossible to maintain the nominal level, pressure or boric acid concentration decreasing in ECCS HA  OR  Leakage of both ECCS HA manhole gaskets  OR  Both ECCS HA SV failed  OR  At least one of FSGV or interlocks activating their closing failed | Changeover the Unit to condition 3  AND  Changeover the Unit to condition 4 | 6 hours  24 hours | | | | 3  4 | | | At the specified rate  At the specified rate | | | |
|  | 3 | Leakage from ECCS HA due to which it is impossible to maintain the nominal level, pressure or boric acid concentration decreasing in ECCS HA  OR  Leakage of both ECCS HA manhole gaskets  OR  Both ECCS HA SV failed  OR  At least one of FSGV or interlocks activating their closing failed | Changeover the Unit to condition 4 | 24 hours | | | | 4 | | | At the specified rate | | | |
| 14.3 | 1 | One ECCS SV failed | To be in condition 1 |  | | | | Current | | | Eliminate the failure during the next SPM | | | |
| 2 | One ECCS SV failed | To be in condition 2 |  | | | | Current | | | Eliminate the failure during the next SPM | | | |
| 3 | One ECCS SV failed | To be in condition 3 |  | | | | Current | | | Eliminate the failure during the next SPM | | | |
|  | 4 | One ECCS SV failed | To be in condition 4 |  | | | | Current | | | Eliminate the failure during the next SPM | | | |
| 14.4 | 1 | ECCS TEH failed | To be in condition 1  AND  Changeover the Unit to condition 2  AND  Changeover the Unit to condition 3  AND  Changeover the Unit to condition 4 | 24 hours  1 hour  6 hours  24 hours | | | | 1  2  3  4 | | | Eliminate the failure  At the specified rate  At the specified rate  At the specified rate | | | |
| 2 | ECCS TEH failed | Changeover the Unit to condition 3  AND  Changeover the Unit to condition 4 | 6 hours  24 hours | | | | 3  4 | | | At the specified rate  At the specified rate | | | |
| 3 | ECCS TEH failed | Changeover the Unit to condition 4 | 24 hours | | | | 4 | | | At the specified rate | | | |
| 14.5 | 1 | Leakage through both ECCS HA TEH sealing gaskets | Changeover the Unit to condition 2  AND  Changeover the Unit to condition 3  AND  Changeover the Unit to condition 4 | 1 hour  6 hours  24 hours | | | | 2  3  4 | | | At the specified rate  At the specified rate  At the specified rate | | | |
| 2 | Leakage through both ECCS HA TEH sealing gaskets | Changeover the Unit to condition 3  AND  Changeover the Unit to condition 4 | 6 hours  24 hours | | | | 3  4 | | | At the specified rate  At the specified rate | | | |
| 3 | Leakage through both ECCS HA TEH sealing gaskets | Changeover the Unit to condition 4 | 24 hours | | | | 4 | | | At the specified rate | | | |
| 15 | YR – emergency gas removal system | | | | | | | | | | | | | |
| 15.1 | 1 OR 2 OR 3 | Leaking of two or several system valves causing non-compensatory pressure or level or temperature increasing in the relief tank | Changeover the Unit to condition 4 until the failure is eliminated | 24 hours | | | | 4 | | | At the specified rate | | | |
| 16 | Emergency power supply system | | | | | | | | | | | | | |
| 16.1 | 1, 2, 3 | А. Failure of one of four channels of the emergency power supply system for the 1st and 2nd reliability group consumers | А1. Recover the channel functioning  А2. Check serviceability of 3 other channels of the safety systems as per the operating instructions (emergency power supply, I&C, TH, TW, TJ, RS etc.)  А3. If А2 is successful – stay in the current condition | 168 hours  72 hours  168 hours | | | current  current  current | | |  | | | | |
|  |  | А4 If in А2 a failure of one channel of any SS is revealed– Changeover the Unit to condition 4  А5. If serviceability as per А1 has not been recovered within the permissible time - Changeover the Unit to condition 4 | 72  24 | | | 4  4 | | | At the specified rate  At the specified rate | | | | |
| 16.2 | 1, 2, 3 | В. Failure of two of four channels of the emergency power supply system for the 1st and 2nd reliability group consumers | В1. Changeover the Unit to condition 4 | 72 hours | | | 4 | | | At the specified rate | | | | |
| 16.3 | 4, 5, 6 | С. One of three on-duty channels failed | С1. Arrange around-the-clock works on serviceability recovery within the shortest period | Until the defect is eliminated | | | current | | |  | | | | |
| 17 | TH15,25,35,45 – emergency boron injection group | | | | | | | | | | | | | |
| 17.1 | 1, 2, 3 | А. One TH15,25,35,45 channel failed | А1. Recovery of the channel functioning  А2. Check serviceability of 3 other channels  А3. If А2 is successful – stay in the current condition  А4. If in А2 a failure of one more channel is revealed – Changeover the Unit to condition 4  А5. If serviceability as per А1 has not been recovered within the permissible time - Changeover the Unit to condition 4 | 168 hours  8 hours  168 hours  72 hours  24 hours | | | current  current  current  4  4 | | | At the specified rate  At the specified rate | | | | |
| 17.2 | 1, 2, 3 | В. Two TH15,25,35,45 channels failed | В1. Changeover the Unit to condition 4 | 72 hours | | | 4 | | | At the specified rate | | | | |
| 18 | TW – Extra borating system | | | | | | | | | | | | | |
| 18.1 | 1, 2, 3 | А. One TW10,20,30,40 channel failed | А1. Recovery of the channel serviceability  А2. Check serviceability of 3 other channels  А3. If А2 is successful – stay in the current condition  А4. If in А2 a failure of one more channel is revealed – Changeover the Unit to condition 4  А5. If serviceability as per А1 has not been recovered within the permissible time - Changeover the Unit to condition 4 | 72 hours  8 hours  72 hours  24 hours  24 hours | | | current  current  current  4  4 | | | At the specified rate  At the specified rate | | | | |
| 19 | Emergency core cooling system TH (passive part – 2nd stage ECCS HA) | | | | | | | | | | | | | |
| 19.1 | 1,2,3 | Leakage from ECCS HA due to which it is impossible to maintain the nominal level, pressure or boric acid concentration decreasing in ECCS HA    OR  ECCS HA SV failed | Changeover the Unit to condition 4 | 24 hours | | | 4 | | | At the specified rate | | | | |
| 20 | TJ – Containment spray system | | | | | | | | | | | | | |
| 20.1 | 1, 2, 3 | А. One TJ system channel failed | А1. Recovery of the channel functioning  А2. Check serviceability of 3 other channels  А3. If А2 is successful – stay in the current condition | 168 hours  8 hours  168 hours | | | current  current  current | | |  | | | | |
|  |  |  | А4. If in А2 a failure of one more channel is revealed – Changeover the Unit to condition 4  А5. If serviceability as per А1 has not been recovered within the permissible time - Changeover the Unit to condition 4 | 72 hours  24 hours | | | 4  4 | | | At the specified rate  At the specified rate | | | | |
| 20.2 | 1, 2, 3 | В. Two TJ system channels failed | В1. Changeover the Unit to condition 4 | 72 hours | | | 4 | | | At the specified rate | | | | |
| 20.3 | 1, 2, 3 | С. Trouble in the chemicals storage system (tanks TH10,20,30,40B004) | С1. Eliminate the defect  С2. Non-fulfillment of C1, Changeover the Unit to condition 4 | 8 hours | | | current  4 | | |  | | | | |
| 20.4 | 4 | D. One of four standby or functioning channels failed | D1. Arrange around-the-clock works on serviceability recovery within the shortest period | Until the defect is eliminated | | | current | | |  | | | | |
| 21 | The emergency and scheduled cool down system –TH10,20,30,40 group | | | | | | | | | | | | | |
| 21.1 | 1, 2, 3 | А. One channel TH10,20,30,40 failed | А1. Recovery of the channel functioning  А2. Check serviceability of 3 other channels  А3. If А2 is successful – stay in the current condition  А4. If in А2 a failure of one more channel is revealed – Changeover the Unit to condition 4  А5. If serviceability as per А1 has not been recovered within the permissible time - Changeover the Unit to condition 4 | 168 hours  8 hours  168 hours  72 hours  24 hours | | | current  current  current  4  4 | | | | | | At the specified rate  At the specified rate | |
| 21.2 | 1, 2, 3 | B. Two channels TH10,20,30,40 failed | В1. Changeover the Unit to condition 4 | 72 hours | | | 4 | | | | | | At the specified rate | |
| 21.3 | 4, 5, 6 | C. One of four standby or functioning channels failed | С1. Arrange around-the-clock works on serviceability recovery within the shortest period | Until the defect is eliminated | | | current | | | | | |  | |
| 22 | RS – emergency make-up water | | | | | | | | | | | | | |
| 22.1 | 1, 2, 3 | А. One channel RS10,20,30,40 failed | А1. Recovery of the channel serviceability  А2. Check serviceability of 3 other channels  А3. If А2 is successful – stay in the current condition  А4. If in А2 a failure of one more channel is revealed – Changeover the Unit to condition 4  А5. If serviceability as per А1 has not been recovered within the permissible time - Changeover the Unit to condition 4 | 168 hours  8 hours  168 hours  72 hours  24 hours | | | current  current  current  4  4 | | | At the specified rate  At the specified rate | | | | |
| 22.2 | 1, 2, 3 | B. Two RS10,20,30,40 channels failed | B1. Recovery of the channel serviceability  В2. Changeover the Unit to condition 4 | 72 hours  8 hours | | | 4 | | | At the specified rate | | | | |
| 23 | Non-cooled coolant cleanup system TC 60,70,80,90 | | | | | | | | | | | | | |
| 23.1 | 1 | Increasing of pressure differential at the sorbent trap ТС60,70,80,90В002 more than  5 kgf/cm2 | Trip (check tripping by protection) the faulty system leg of ТС60-90 system of this loop | Immediately | | | current | | | Eliminate the failure during the next SPM | | | | |
| 23.2 | 2, 3 | Increasing of pressure differential at the sorbent trap ТС60,70,80,90В002 more than  0,49 MPa (5 kgf/cm2) | Trip (check tripping by protection) the faulty system leg of ТС60-90 system of this loop | Immediately | | | current | | | Eliminate the failure during the next SPM | | | | |
| 23.3 | 1,2,3 | Pressure differential increasing at filter ТС60,70,80,90В001 more than 0,4 MPa (3,92 kgf/cm2) | Trip faulty leg of ТС60-90 system of this loop | Immediately | | | current | | | Eliminate the failure during the next SPM | | | | |
| 24 | TF – nuclear component cooling system | | | | | | | | | | | | | |
| 24.1 | 1, 2, 3 | А. One channel TF10,20,30,40 failed | А1. Recovery of the channel functioning  А2. Check serviceability of 3 other channels  А3. If А2 is successful – stay in the current condition  А4 If in А2 a failure of one channel of any SS is revealed – Changeover the Unit to condition 4  А5. If serviceability as per А1 has not been recovered within the permissible time - Changeover the Unit to condition 4 | 168 hours  72 hours  168 hours  72 hours  24 hours | | | current  current  current  4  4 | | | At the specified rate  At the specified rate | | | | |
| 24.2 | 1, 2, 3 | B. Two channels TF10,20,30,40 failed | В1. Recovery of the channel functioning  В2. Changeover the Unit to condition 4 | 72 hours  8 hours | | | current  4 | | | At the specified rate | | | | |
| 24.3 | 4, 5, 6 | C. One of four standby or functioning channels failed | C1. Arrange around-the-clock works on serviceability recovery within the shortest period | Until the defect is eliminated | | | current | | |  | | | | |
| 25 | TH – borated water storage system | | | | | | | | | | | | | |
| 25.1 | 1, 2, 3 | А. Deviation of boric acid concentration in any tank TH10(20,30,40)В001,002 from the permissible values (see Table F6, F7 of App.F) or decreasing of the boric acid stock | А1. Restore the nominal parameters  А2. If А1 is not fulfilled - Changeover the Unit to condition 4 | 168 hours  24 hours | | | current  4 | | |  | | | | |
| 25.2 | 1, 2, 3 | A In two tanks of one channel:  Boric solution concentration is less than 16 g/dm3  OR  Boric solution temperature is less than 25 оС  OR  Boric solution level is less than 13,0 m  В In tanks of two channels:  Boric solution concentration is less than 16 g/dm3  OR  Boric solution temperature is less than 25 оС  OR  Boric solution level is less than 13,0 m  С Required activities of А or B and the relevant completion time are not fulfilled | A.1 Perform non-scheduled check of the other channels  AND  Recover channel up to serviceable condition  В.1 Perform non-scheduled check of the other channels AND В.2 Recover channel up to serviceable condition  С.1 Changeover to condition 4 | 8 hours  168 hours  72 hours  24 hours | | | current  current  current  4 | | |  | | | | |
| 26 | TH18,28,38,48 – SFP cooling system | | | | | | | | | | | | | |
| 26.1 | 1, 2, 3 | А. Level drop in the fuel pool to minimum acceptable | A1 Restore the level  А2 If the leakage is jet, changeover to condition 4 | 4 hours | | | current  4 | | |  | | | | |
| 26.2 | 4, 5, 6 | Level signal occurrence in the leakage collection tank of FP liner TH75B001 | Stay in the current condition until the failure is eliminated | 4 hours | | | current | | |  | | | | |
| 26.3 | 1, 2, 3 | В. Failure of one redundant channel TH18(28,38,48) | В1 Withdraw faulty equipment to repair for the time not more than 168 hours | 168 hours | | | current | | |  | | | | |
| 26.4 | 1, 2, 3 | С. Failure of two redundant channels TH18(28,38,48) | С1 Withdraw faulty equipment to repair for the time not more than 72 hours | 72 hours | | | current | | |  | | | | |
| 26.5 | 1, 2, 3 | Fuel pool liner leakage is more than 50 l/days from one section  OR  more than 1 l/days via every hydroseal | To be in current condition | 4 hours | | |  | | | Possibility of further Unit operation at power shall be defined by CEP | | | | |
| 27 | TМ – Compressed air supply system for air-actuated valves | | | | | | | | | | | | | |
| 27.1 | 1, 2, 3 | А. Failure of one compressor supplying air to TM system | А1. Compressor functioning recovery | Until the defect is eliminated | | | current | | |  | | | | |
| 27.2 | 1, 2, 3 | В. Failure of two compressors supplying air to TM system | В1. Recover functioning of at least one compressor  В2. If functioning as per В1 is not recovered within the permisible time – Changeover the Unit to condition 4 | 10 hours  Immediately | | | current  4 | | |  | | | | |
| 28 | TА – volume control system | | | | | | | | | | | | | |
| 28.1 | 1, 2, 3 | А. One of make-up pumps TА31,32,33D001 failed | А1. Restore the pump functioning | Until the defect is eliminated | | | current | | |  | | | | |
| 28.2 | 1,2 | B. Three make-up pumps TА31,32,33D001 failed | В1. Changeover the Unit to condition 4 | Immediately | | | 4 | | | Emergency shutdown by EP key | | | | |
| 28.3 | 1, 2, 3 | C. Failure of deaerator TА10В003 effecting to the make-up and blow-down process | C1. Changeover the Unit to condition 4 | Until the defect is eliminated | | | 4 | | |  | | | | |
| 29 | TD – coolant storage and treatment system | | | | | | | | | | | | | |
| 29.1 | 1, 2, 3 | А. Failure of one pump TD21,22D001 | А1. Recover serviceability of the pump | Until the defect is eliminated | | | current | | |  | | | | |
| 29.2 | 1, 2, 3 | В. Failure of two pumps TD21,22D001 | В1 Recover serviceability of at least one pump  В2. If В1is not fulfilled - changeover the Unit to condition 4 | 72 hours  24 hours | | | current  4 | | |  | | | | |
| 30 | TВ – chemicals control system | | | | | | | | | | | | | |
| 30.1 | 1, 2, 3 | А. Deviation of boric acid concentration in any tank TВ20В001(002) from the permissible values or boric acid stock decreasing less than 60 m3. | А1. Restore the nominal parameters  А2. If А1 is not fulfilled - changeover the Unit to condition 4 | 24 hours  72 hours | | | current  4 | | |  | | | | |
| 30.2 | 1, 2, 3 | А. One pump TВ21D001(002) failed | А1. Restore the pump functioning | Until the defect is eliminated | | | current | | |  | | | | |
| 30.3 | 1, 2, 3 | В. Two pumps TВ21D001,002 failed | В1 Restore the pumps functioning  В2. If В1 is not fulfilled – changeover the unit to condition 4 | 24 hours  24 hours | | | current  4 | | |  | | | | |
| 31 | TS10 – hydrogen ignition system | | | | | | | | | | | | | |
| 31.1 | 1, 2, 3 | А. One channel TS10 failed | А1. Restore the channel functioning  А2. If А1 is not fulfilled, changeover the Unit to condition 4 | 72 hours | | | current  4 | | | At the specified rate | | | | |
| 32 | TS20 – radioactive gas purification system | | | | | | | | | | | | | |
| 32.1 | 1, 2, 3 | А. One leg TS20 failed | А1. Changeover blow-off to the serviceable leg | Until the defect is eliminated | | | current | | |  | | | | |
| 32.2 | 1, 2, 3 | В. Two legs TS20 failed | В1. Changeover the Unit to condition 4 | Until the defect is eliminated | | | 4 | | |  | | | | |
| 33 | TK – gas blow-off system | | | | | | | | | | | | | |
| 33.1 | 1, 2, 3 | А. Failure of blow-off from relief tankYP20B001 | А1. Changeover the Unit to condition 4 | Until the defect is eliminated | | | 4 | | |  | | | | |
| 34 | Nuclear equipment drain system in reactor compartment (TY-1) and in ZC (TY-2) | | | | | | | | | | | | | |
| 34.1 | 1, 2, 3 | А. Failure of one pump TY21(22)D001  or TY31(32)D001 | А1. Restore the pump functioning  А2. If А1 is not fulfilled, changeover the Unit to condition 4 | 72 hours | | | current  4 | | | At the specified rate | | | | |
| 34.2 | 1, 2, 3 | В. Failure of two pumps TY21(22)D001  or TY31(32)D001 | В1. Changeover the Unit to condition 4 | 24 hours | | | 4 | | |  | | | | |
| 34.3 | 1, 2, 3 | С. Heat-exchanger TY10B001 failed | С1. Changeover to condition 4 | 24 hours | | | 4 | | |  | | | | |
| 34.4 | 1, 2, 3 | D. Leakage of drain tanks TY21(22)В001 or controlled leakage tanks TY30B001 | D1. Changeover the Unit to condition 4 | 24 hours | | |  | | |  | | | | |
| 35 | VЕ – service water supply system | | | | | | | | | | | | | |
| 35.1 | 1, 2, 3 | А. One channel VЕ10,20,30,40 failed | А1. Recovery of the channel functioning  А2. Check serviceability of 3 other channels  А3. If А2 is successful – stay in the cur-rent condition  А4 If in А2 a failure of one channel of any SS is revealed – Changeover the Unit to condition 4 | 168 hours  72 hours  168 hours  24 hours | | | current  current  current  4 | | |  | | | | |
| 35.2 | 1, 2, 3 | B. Two channels VЕ10,20,30,40 failed | B1. Recovery of the channel functioning  B2. Changeover the Unit to condition 4 | 72 hours  8 hours | | | current  4 | | | At the specified rate | | | | |
| 35.3 | 4, 5, 6 | C. One of three on-duty or functioning VE system channels failed | C1. Arrange around-the-clock works on serviceability recovery within the shortest period | Until the defect is eliminated | | | current | | |  | | | | |
| 36 | VJ – reliable cooling water system | | | | | | | | | | | | | |
| 36.1 | 1, 2, 3 | А. One channel VJ10,20,30,40 failed | А1. Recovery of the channel functioning  А2. Check serviceability of 3 other channels  А3. If А2 is successful – stay in the current condition  А4 If in А2 a failure of one channel of any SS is revealed – Changeover the Unit to condition 4  А5. If as per A1 serviceability is not recovered within the permissible time - changeover the Unit to condition 4 | 168 hours  8 hours  168 hours  72 hours  24 hours | | | current  current  current  4  4 | | | At the specified rate  At the specified rate | | | | |
| 36.2 | 1, 2, 3 | B. Two channels VJ10,20,30,40 failed | B1. Recovery of the channel functioning  B2. Changeover the Unit to condition 4 | 72 hours  8 hours | | | current  4 | | | At the specified rate | | | | |
| 36.3 | 4, 5, 6 | C. One of three on-duty or functioning VE system channels failed | C1. Arrange around-the-clock works on serviceability recovery within the shortest period | Until the defect is eliminated | | | current | | |  | | | | |
| 37 | TL03 – recirculation system for cooling the reactor cavity, SG boxes and RCPS | | | | | | | | | | | | | |
| 37.1 | 1, 2, 3 | А. failure of one or two fans TL03 | А1.Stay in current condition, restore functioning during SPM |  | | | current | | |  | | | | |
| 37.2 | 1, 2, 3 | В. TL03 system failure | В1. Changeover the Unit to condition 4 | 24 hours | | | 4 | | |  | | | | |
| 38 | TL13 - – recirculation CPS drives cooling system | | | | | | | | | | | | | |
| 38.1 | 1, 2, 3 | А. One TL13 channel failed | А1. Recover the channel functioning | Until the defect is eliminated | | | current | | |  | | | | |
| 38.2 | 1, 2, 3 | В. Two TL13 channels failed | В1. Recover the channel functioning  В2. If В1 is not fulfilled or upon expiration of time, changeover the Unit to condition 4 | 72 hours | | | current  4 | | | At the specified rate | | | | |
| 38.3 | 1, 2, 3 | С. Three TL13 channels failed | С1. Changeover to condition 4 | Immediately | | | 4 | | |  | | | | |
| 39 | TL09,21 – rarefication creation system in the reactor building containment | | | | | | | | | | | | | |
| 39.1 | 1, 2, 3 | А. System TL09,21failed | А1. Recover serviceability  AND  А2. At rarefication decreasing less than  150 Pa – changeover the Unit to condition 4 | 72 hours  24 hours | | | current  4 | | |  | | | | |
| 40 | TL08 – air cooling systems in premises of ZB building TL08D001, TL08D031, TL08D032 | | | | | | | | | | | | | |
| 40.1 | 1, 2, 3 | А. Ventilation of one safety channel TL08 failed | А1. Recovery of the channel functioning  А2. Check serviceability of 3 other channels of the safety systems ventilation located in the respective premises (TH, TW, TJ, TF) | 168 hour  72 hours | | | current  current | | |  | | | | |
|  |  |  | А3. If А2 is successful – stay in current condition  А4 If in А2 failure of one channel of any SS is revealed – changeover the Unit to condition 4  А5. If as per A1 serviceability is not recovered within the permissible time - changeover the Unit to condition 4 | 168 hours  24 hours  24 | | | current  4  4 | | | At the specified rate  At the specified rate | | | | |
| 40.2 | 1, 2, 3 | В. Ventilation of two channels TL08 failed | В1. Changeover the Unit to condition 4 | 24 hours | | | 4 | | | At the specified rate | | | | |
| 40.3 | 4, 5, 6 | С. One of three on-duty or functioning ventilation channels failed | С1. Arrange around-the-clock works on serviceability recovery within the shortest period | Until the defect is eliminated | | | current | | |  | | | | |
| 41 | RF31,41B001 – high pressure heaters system | | | | | | | | | | | | | |
| 41.1 | 1 | А. HPH tripping | А1. Maintain feed water temperature not less than 160 оС | Until the defect is eliminated | | | 1 | | |  | | | | |
| 42 | UB – the turbine condensate demineralizing system | | | | | | | | | | | | | |
| 42.1 | 1 | А. Condensate temperature increasing prior to UB filters is more than 55 оС | А1. Eliminate the failure  А2. If А1is not fulfilled, decrease power up to the level, at which condensate temperature will be not more than 55 оС or trip UDP filters observing WC | 8 hours | | | 1 | | | At the specified rate | | | | |
| 42.2 | 1 | В. UDP failure without violating secondary circuit WC norms | В1. Eliminate the failure | Until the defect is eliminated | | | 1 | | |  | | | | |
| 42.3 | 1,2,3 | Malfunction in the system causing deviation of one or several secondary circuit coolant rated quality indices | AS per Appendix F |  | | |  | | |  | | | | |
| 43 | RL – feed water pumps LAC11,12,13,14,15,16 | | | | | | | | | | | | | |
| 43.1 | 1 | D. Failure of one AFWP | D1. Eliminate the failure | Until the defect is eliminated | | | 1 | | |  | | | | |
| 43.2 | 1, 2, 3 | E. Increasing of oxygen concentration in feed water up to 50 mkg/kg | Е1. Changeover to condition 4 | Until the defect is eliminated | | | 4 | | |  | | | | |
| 43.3 | 1, 2, 3 | F. Increasing of hydrogen ion polished feed water sample electric conductivity in SG up to 1 µCM/cm | F1. Changeover to condition 4 | Until the defect is eliminated | | | 4 | | |  | | | | |
| 44 | RQ – auxiliary steam system | | | | | | | | | | | | | |
| 44.1 | 1 | В. BRU-SN failed | В1. Restore functioning  В2. If В1 is not fulfilled, changeover to condition 4 | 72 hours  24 hours | | | 1  4 | | |  | | | | |
| 45 | VC – the main cooling water system | | | | | | | | | | | | | |
| 45.1 | 1 | A. Water leakage at the pump pressure pipeline damaging which may cause flooding of the turbine building premises | А1. Shutdown the pumps, changeover the Unit to condition 4 | 24 hours | | | 4 | | |  | | | | |
| 46 | Confinement | | | | | | | | | | | | | |
| 46.1 | 1, 2, 3 | А. Containment integrity is violated | А1. Restore the containment integrity  А2. If А1 is not fulfilled, changeover the Unit to condition 4 | 1 hour  24 hours | | | current  4 | | |  | | | | |
| 46.2 | 1, 2, 3 | В. Temperature and pressure in the annulus do not correspond to the design limits | В1. Restore rarefication in the gap between shells within 100-400 Pa  AND  Temperature in the annulus within + 10 °С to +55 °С  В2. If В1 is not fulfilled or upon expiration of time, changeover the Unit to condition 4 | 72 hours  24 hours | | | current  4 | | |  | | | | |
| 47 | Radioactive releases and wastes | | | | | | | | | | | | | |
| 47.1 | 1, 2, 3, 4, 5, 6 | А. Exceeding the radioactive releases or wastes over the permitted check releases and permitted check wastes | А1. Start corrective actions and eliminate the reason for NOC disturbance | Immediately | | | current | | |  | | | | |
| 48 | TLSU | | | | | | | | | | | | | |
| 48.1 | 1, 2, 3 | А. One workstation of the monitoring system failed | А1. Restore functioning  А2. If А1 is not fulfilled being at power in condition 1 reduce power up to   90% Nnom | 72 hours  168 hours Until the defect is eliminated by Chief Engineer directive | | | current  current | | |  | | | | |
| 48.2 | 1, 2, 3 | В. A part or the whole TLSU is unserviceable by one of instrumentation and control functions, which does not allow to obtain the required data or generate a command at LERC or LETC workstation | В1. Terminate the activities on the Unit operation mode change  AND  Monitor RP steady state by devices and indicators at safety panels and at the redundant area including GMP. Recover serviceability  В2. If В1 is not fulfilled, changeover the Unit to condition 4 controlling cool-down from the redundant area of MCR panels | Immediately  2 hours  24 hours | | | current  current  4 | | | At the specified rate | | | | |
| 49 | ESFIP | | | | | | | | | | | | | |
| 49.1 | 1, 2, 3 | А. One of four ESFIP channels failed | А1. Recover the channel functioning  А2. Check serviceability of 3 other channels of the safety systems as per the operating instructions (emergency power supply, I&C, TH, TW, TJ, RS)  А3. If А2 is successful – stay in the current condition  А4 If in А2 a failure of one channel of any SS is revealed – Changeover the Unit to condition 4 | 72 hour  24 hours  72 hours  24 hours | | | current  current  current  4 | | | At the specified rate | | | | |
|  |  |  | А5. If serviceability as per A1 is nor recovered within the permissible time - Changeover the Unit to condition 4 | 24 hours | | | 4 | | | At the specified rate | | | | |
| 49.2 | 1, 2, 3 | В. Two of four ESFIP channels failed | В1. Changeover the Unit to condition 4 | 24 hours | | | 4 | | | At the specified rate | | | | |
| 49.3 | 4, 5, 6 | С. One of three on-duty channels failed | С1. Arrange around-the-clock works on serviceability recovery within the shortest period | Until the defect is eliminated | | | current | | |  | | | | |
| 50 | MCDS | | | | | | | | | | | | | |
| 50.1 | 1 | Failure of one SHW channel | Operation at the steady level of power.  Upon expiration of time reducing of power up to 30% Nnom | 8 hours | | | 1 | | | At the specified rate | | | | |
| 50.2 | 1 | Failure of two SHW channels | Reducing of power up to 30% Nnom | Immediately | | | 1 | | | At the specified rate | | | | |
| 50.3 | 1 | Failure of three and more SHW channels | Upon expiration of time reducing of power up to 30% Nnom | Immediately | | | 1 | | |  | | | | |
| 50.4 | 1 | Failure of one SHW rack | Operation at the steady level of power. | Until the failure is eliminated | | | 1 | | |  | | | | |
| 50.5 | 1 | Failure of the terminal cabinet or two SHW racks | Operation at the steady level of power.  If the failure is not eliminated within the specified period of time, reduce the reactor power up to 98% of the nominal one. | 8 hours | | | 1 | | |  | | | | |
| 50.6 | 1 | Failure of one CC ICIS | Operation at the steady level of power. | Until the failure is eliminated | | | 1 | | |  | | | | |
| 50.7 | 1 | Failure of two CC ICIS | Operation at the steady level of power.  AND  if the failure is not eliminated, reduce the reactor power up to 90% of the nominal one  Upon expiration of time, changeover to condition 3 | 2 hours  16 hours | | | 1  3 | | | At the specified rate | | | | |
| 50.8 | 1 (2, 3) | Failure of SHW ALMS | Operation at the steady level of power or at the nominal parameters | 72 hours | | | 1 (2, 3) | | |  | | | | |
| 50.9 | 1 (2, 3) | Failure of SHW LMS-H | Operation at the steady level of power or at the nominal parameters | 72 hours | | | 1 (2, 3) | | |  | | | | |
| 50.10 | 1 (2, 3) | Failure of SHW ALMS and SHW LMS-H | Operation at the steady level of power or at the nominal parameters.  Upon expiration of time, changeover to condition 4 | 72 hours | | | 1 (2, 3) | | | At the specified rate | | | | |
| 51 | **ALMS, LMS-H** | | | | | | | | | | | | | |
| 51.1 | 1 | Occurrence of leakage in the pipelines, covered by LBB:  - MCP;  - connecting pipeline;  - ECCS pipeline.  LMS-H and/or ALMS have been registered (equipment and pipelines status indicator is flashing by «yellow color» at the main video-frame of TLSU monitor) | 1. Check the information on leakage availability presented at additional video-frames of TLSU monitor.  2. Upon leakage confirmation, changeover the Unit to condition 4. | | 1 hour | | 4 | | | At the specified rate | | | | |
| 51.2 | 1 | Full failure of one of ALMS or LMS-H systems (failure of all system sensors providing leakage detection at one of 17 controlled pipelines or failure of the system SHWS) | 1. Take measures for the system functioning recovery.  2. If it is impossible to eliminate the failure within the specified time, changeover the Unit to condition 4. | | 30 days | | 4 | | | At the specified rate | | | | |
| 51.3 | 1 | Failure of the second ALMS or LMS-H system (failure of all system sensors providing leakage detection at one of 17 controlled pipelines or failure of the system SHWS) within 30 days after failure of one of the system. | 1. Take measures for the system functioning recovery.  2. If it is impossible to eliminate the failure within the specified time, changeover the Unit to condition 4. | | 1 hour | | 4 | | | At the specified rate | | | | |
| 52 | **Post accident monitoring system** | | | | | | | | | | | | | |
| 52.1 | 1, 2, 3 | А. Failure of one information channel | А1. Recovery of the channel serviceability  А2. Changeover the Unit to condition 4 | | | 168 hours  12 hours | current  4 | | | At the specified rate | | | | |
| 52.2 | 1, 2, 3 | B. Failure of two information channels | В1. Recovery of the channels serviceability  В2. Changeover the Unit to condition 4 | | | 72 hours  12 hours | current  4 | | | At the specified rate | | | | |
| In case CPS cabinet goes out of order, it is necessary to estimate the loss of equipment controlled form this cabinet and take a decision on further operation | | | | | | | | | | | | | | |
| 53 | Nonoperability of the turbine plant main equipment that lead to limitation of RP power. | | | | | | | | | | | | | |
| 53.1 | SA – turbine plant | | | | | | | | | | | | | |
| 53.1.1 | 1 | А. Tripped condition of the turbine in regards of steam (2 TG SV out of 4 are closed) | А1. Decrease RP power to 40% Nnom. | | | Immediately | current | | | RP power shall be decreased by concurrent operation of APP\*, ROM, PP-1 together with EPCS. | | | | |
| 53.2 | RL – feedwater electric pumps RL12,22,32D001 | | | | | | | | | | | | | |
| 53.2.1 | 1 | А. Tripping of one feedwater pump in case the standby pump fails to actuate | А1. Decrease power to 50 % and maintain it | | | Immediately | 1  until the failure is eliminated | | | “Decrease of RP power by APP\* and ROM, PP-1 equipment together with EPCS by signal “Unloading 5” in SLPE” | | | | |
| 53.2.2 | 1 | В. Inoperability of two feedwater pumps in case the standby pump fails to actuate | В1. In case RP power is more than 25% from the rated value, press EP buttons of set 1,2.  B2.Decrease power to 6 % and maintain it | | | Immediately | 3  until the failure is eliminated  1  until the failure is eliminated | | | Decrease of RP power by APP\* and ROM, PP-1 equipment together with EPCS by signal “Unloading 10” in SLPE» | | | | |
| 53.2.3 | 1 | С. Inoperability of all feedwater pumps | С1. In case RP power is more than 25% from the rated value, press EP buttons of set 1,2.  С2.Decrease power to 5% and maintain it | | | Immediately | 3  until the failure is eliminated  1  until the failure is eliminated | | | Decrease of RP power by APP\* and ROM, PP-1 equipment together with EPCS by signal “Unloading 10” in SLPE» | | | | |
| 53.3 | VC – circulation pumps VC10,20,30,40D001 | | | | | | | | | | | | | |
| 53.3.1 | 1 | А. Inoperability of one out of 4 operating circulation pumps | А1. Automatic decreasing of TG electrical power 800 mW by means of EPCS | | | Immediately | 1  Until the failure is eliminated | | | RP unloading is performed by APR operation in T mode.  In case APR is tripped or failed, RP unloading shall be performed by buttons PP-1 to N=80÷85% Nnom. | | | | |
| 53.3.2 | 1 | В. Inoperability of two (one for each condenser) out 4 operating circulation pumps | В1. Automatic decreasing of TG electrical power 600 mW by means of EPCS | | | Immediately | 1  Until the failure is eliminated | | | RP unloading is performed by APR operation in T mode.  In case APR is tripped or failed, RP unloading shall be performed by buttons PP-1 to N=60÷65% Nnom. | | | | |
| 53.3.3 | 1 | С. Inoperability of more than two out of 4 operating circulation pumps | С1. Operation of TU is forbidden. Close TU SV, monitor unloading of RP to 40% Nnom | | | Immediately | 1  Until the failure is eliminated | | | RP power shall be decreased by concurrent operation of APP\*, ROM, PP-1 together with EPCS. | | | | |
| 53.4 | RM – Condensate electric pumps RM11,12,13D001. | | | | | | | | | | | | | |
| 53.4.1 | 1 | А. Inoperability of CEP (one CEP remained in operation) | А1. Automatic decreasing of TG electrical power 600 mW by means of EPCS | | | Immediately | 1  Until the failure is eliminated | | | RP unloading is performed by APR operation in T mode.  In case APR is tripped or failed, RP unloading shall be performed by buttons PP-1 to N=60÷65% Nnom. | | | | |
| 53.4.2 | 1 | В. Inoperability of all CEP | В1. Trip TU by setting TU SV. Monitor RP unloading to 40% С.  В2. Continue RP unloading from PP-1 to 1÷2 % Nnom. | | | Immediately | 1  Until the failure is eliminated | | | RP unloading shall be performed from PP-1 until the level in deaerator RF60B001 is stabilized. In case the level in RF60B001 drops below 1300 mm, monitor tripping of FP, if N is more than 25% Nnom, trip RP from EP switch. | | | | |
| 53 | RG – separate fluid drainage system | | | | | | | | | | | | | |
| 53.5.1 | 1 | Tripping of all separate fluid drain pumps RG12,22,32D001 at RP power level more than 50% Nnom. | A1. Decrease RP power to 50% Nnom. | | | Immediately | current | | | Power shall be decreased by PP-1 control switch | | | | |
| 53.5.2 | 1 | One of the separate fluid drain pumps RG12,22,32D001 remained in operation at RP power level more than 75% Nnom. | Decrease RP power to 75% Nnom. | | | Immediately | current | | | Power shall be decreased by PP-1 control switch | | | | |
| 54 | Inoperability of the electrical circuit equipment, leading to RP power limitation. | | | | | | | | | | | | | |
| 54.1.1 | 1 | А. Tripping of generator 10SP10 from the grid. Tripped condition of generator circuit breakers 27 kV 10AQ01,02. | А1. Decrease RP power to 40% Nnom. | | | Immediately | 1  Until the failure is eliminated | | | RP power shall be decreased by concurrent operation of APP\*, ROM, PP-1 together with EPCS. | | | | |
| 54.2.1 | 1 | А. Inoperability of one unit transformer | А1. Automatic decreasing of TG electrical power 700 mW by means of EPCS | | | Immediately | 1  Until the failure is eliminated | | | RP unloading is performed by APR operation in T mode.  In case APR is tripped or failed, RP unloading shall be performed by buttons PP-1 to N=70÷75% Nnom. | | | | |
| 54.3.1 | 1 | А. Loss of connection with the energy system by 400 kV line. | А1. Decrease RP power to 40% Nnom. | | | Immediately | 1  Until the failure is eliminated | | | RP power shall be decreased by concurrent operation of APP\*, ROM, PP-1 together with EPCS. | | | | |
| APP\* - power setback from APP shall only be controlled when RP power by NFME is higher than or equals 75 % of rated value. If the power is less than 75 % of rated value, RP power setback is performed by ROM, PP-1. | | | | | | | | | | | | | | |

5.1.4 Additionally the following conditions shall be fulfilled:

#### 5.1.4.1 It is forbidden to operate SIS of the Unit if its serviceability parameters deviates from the values defined for normal conditions. The permissible time for withdrawal such equipment for repair at the Unit functioning is defined in Table.5.1.

#### 5.1.4.2 To provide for the required temperature difference between water of the primary circuit cold leg and make-up water in the nominal operation mode is less than 30 °С, it is forbidden to exceed make-up flow-rate over blow-down flow-rate to more than 14 m3/hr (except for the emergency modes with the primary circuit leakages).

#### 5.1.4.3 Temperature at the output of the upper unit shall not exceed 115°С. In case of deviations more than the specified value, take measures to decrease temperature, if possible, by agreement with CE, DOD start unloading RP to bring down the temperature at the outlet of the upper unit to the standard value 115°С.

#### 5.1.4.4 During functioning APC shall provide maintaining the defined pressure value in the secondary circuit (steam header) with the controller insensitivity zone not more than ±0,05 MPa (not more than ±0,6 kgf/cm2) and maintaining the neutron flux density level with insensitivity zone not more than ±2% of the nominal value. At the same time, pressure deviation from the nominal value in the steady state shall not exceed ±0,1 MPa (not more than ±1 kgf/cm2) taking into account the insensitivity zone, the parameter measurement error and parameter deviation during controlling, as well as deviation from the defined neutron flux value in the process of marinating the steady value shall not exceed ±2% of the nominal value.

5.1.5 Operation in the lifetime stretch-out mode using reactivity power effect:

1) fuel operation conditions:

a) for FA at 1 year operation duration - not more than 8000 eff. h.;

b) for FA at 3 year operation duration - not more than 22500 eff. h.;

c) for FA at 4 year operation duration - not more than 30000 eff. h.;

d) maximally-permissible designed fuel burn-up depth average per FA – not more than 49 MW×day/kg U.

Prior to the Unit operation using reactivity power effect, the reactor neutron-physics characteristics calculations shall be performed and agreed at NPP.

2) The Unit operation in the mode of lifetime stretch-out using reactivity power effect is allowed within not more than 30 effective days.

At the same time power reducing shall not exceed 30 % of the nominal power level meeting the following requirements:

a) primary and secondary circuit pressure and the coolant temperature at the reactor bottom shall be maintained at the nominal level.

It is not allowed to withdraw CPS CR operating group higher than 95 % from the core bottom. At operation at reactivity power effect CPS CR operating group withdrawal shall not exceed 5 % of the core height within one day.

b) by measure of the reactor power variation at the Unit operation at reactivity power effect, the emergency protection activation setpoint for the neutron power shall be set to 7 % over the current power value.

At discrepancy between the power values as per NFME and the thermal power of the reactor to more than 1 %, perform NFME calibration.

c) at the emergency protection activation, bring boric acid concentration to correspondence with the data of NPC album at the end of the fuel burn-up.

The reactor shall be brought to MCL after taking-up CPS CR by boric acid removal at working position of CPS CR control group.

#### 5.1.6 The Unit operation as per ICIS condition

#### 5.1.6.1 After refueling, reaching the nominal power is allowed only at availability of completely serviceable ICIS soft-and hardware and at least 90 % serviceable ICDS.

#### 5.1.6.2 Failure of ICI sensors restricts possibility to perform the control functions for the core area the sensors of which are faulty.

#### A sensor is considered to be faulty, if it does not produce the valid information on the controlled parameter by the reason of malfunctioning of the sensor itself or its communication circuits.

#### To analyze the consequences of the in-core sensor failure for the core control quality in the process of operation, it is necessary to take into account their design location in the core and NFTMC binding to the coordinates of the sections. There are 163×7 sections of the core volume controlled by 378 SPND, 100 TC at FA outlet and 46 TC at FA inlet.

#### In case of in-core sensors failure in ICDS it is necessary:

#### 1) to define the limit of the sensors damaging and availability of control for each core section using SPND;

#### 2) if there is no control for one and more sections, using SPND define the required reducing of the permissible level of the reactor power.

#### 5.1.6.3 Conditions of the permissible reactor power level

#### 1) At complete loss of the core condition control by readings of the in-core sensors for the time not more than two hours, it is required to maintain the steady state and the level of the core thermal power. Upon expiration of two hours, the reactor plant shall be changed over to “cold” condition.

#### 2) At failure of the in-core sensors it is required:

#### a) upon reaching the second stage of “degradation” (see Appendix J) and keeping 90 % of thermocouples, it is necessary to decrease RP power up to 90 % Nnom and periodically (at least once per hour) analyze the core condition by the following parameters:

#### - signals of PV chambers;

#### - the cluster position sensor in the uncontrolled sector;

#### - coolant temperature in the hot leg which is the most close proximity to this sector of the loop;

#### - primary circuit pressure;

- upon reaching the second stage of «degradation» and simultaneous occurrence of any transient mode features, it is required to reduce power up to 85% of the nominal one;

b) upon reaching the third stage of “ degradation” and keeping 90 % of thermocouples, if any features of transient mode appeared, or in case of thermocouples failure in the amount more than 10 %, but mot more than 50 %, it is required to reduce power up to 80 % of the nominal one;

- upon reaching the third stage of «degradation» and simultaneous occurrence of any transient mode features, it is required to reduce power up to 70 % of the nominal one;

#### c) upon reaching the fourth stage of “degradation”, the reactor shall be changed over to «hot» standby mode;

#### d) at failure of more than 50 % of thermocouples located at the outlet of the FA or upon reaching 4th stage of “degradation” and failure of thermocouples in the amount more than 30 %, but not more than 50 %, changeover RP to “cold” condition.

5.1.7 Conditions of repair works performance when the Unit is at power operation

#### 5.1.7.1 During the Unit operation at power and revealing a malfunction in any of SS channel element, no later than in one hour from the moment of the malfunction reveal, the MCR personnel shall:

1) Define if the malfunction effects to SS channel serviceability.

2) If SS channel failed, by turns confirm serviceability of the similar devices, similar equipment of the other SS channels:

a) if pumps of the protective SS failed, the pumps of three on-duty channels of this system shall be checked for recirculation, at malfunction of supporting SS pumps, operation of pumps of another three channels of this system shall be monitored (if they are in operation) or checked for recirculation (if they are in standby);

b) if failure is revealed in the remote control by the mechanisms of one SS channel, only remote control from MCR by these mechanisms in three other channels of this SS shall be checked;

c) if one channel of the emergency power supply of the 1st and 2nd reliability group consumers failed, alternate check shall be performed with the startup by the sequential startup program for all safety system mechanisms fed from three other channels of the reliable power supply system;

d) During SS channel check, availability of power supply and serviceability of process alarm shall be checked, as well as I&C and availability of information presentation at I&C and individual devices, proper I&C capability to perform the defined functions including information presentation for the operative personnel and event recording.

e) After SS channel check, its mechanisms and equipment shall be changed over to a condition corresponding to the requirements of the design and the operating instructions for the Unit power operation modes.

3) After performing the checks and serviceability confirmation for three other SS channels, it is allowed to withdraw the faulty element for repair for the period not more than 168 hours (7 days) from the moment of the failure reveal.

The Unit operation at power within 168 hours (7 days) at availability of three on-duty SS channels in condition when their serviceability is confirmed, is not considered as violation of the safety Unit operation conditions.

4) Upon elimination of failure, the failed channel shall be checked for serviceability. The time required to check serviceability of the restored SS channel is included into permissible repair period.

5) If the designed process SS function serviceability may not be confirmed, or upon expiration of time for SS channel withdrawal to repair, the Unit shall be unloaded in the normal process sequence and changed over to “cold” condition.

6) If failure is revealed in two SS channels, the Unit shall be shutdown and changed over to “cold” condition at the maximally permissible rate.

#### 5.1.7.2 If failure is revealed in the sequential startup automatics system of one of four safety system channels, it is allowed:

1) not to withdraw the channel from operation, if one element in one of two diversitets is damaged (time of the element replacement does not exceed 1 hour and the replacement may be performed at the functioning channel);

2) to withdraw the channel for the time of the damage elimination at failure in the output circuits of the sequential startup automatics set;

3) to withdraw the channel at damaging of one of the system sensors for the time of the damage elimination;

If damage elimination time does not exceed 24 hours from the moment of failure reveal, it is allowed not to test three other channels.

If the failure is not eliminated within the specified period, the repair activities may be extended up to 168 hours at the mandatory testing of three safety system channels being in operation.

#### 5.1.7.3 During the Unit operation at power and revealing a failure of the redundant equipment of the normal operation systems important to safety, it is allowed to withdraw the faulty equipment for repair observing the conditions specified in Table 5.1.3.1.

#### 5.1.7.4 During the Unit operation at power and revealing a failure of the non-redundant equipment of the normal operation systems important to safety, withdrawal the faulty equipment to repair is a allowed only by permission of the chief engineer.

#### 5.1.7.5 If there is a failure of the remote control devices, protections and interlocks of the process equipment of normal operation important to safety, and elimination of failure requires withdrawal of the process equipment from operation (from on-duty), the failure shall be eliminated as per the requirements of Table 5.1.3.1

#### 5.1.7.6 The electrical equipment of NPP main schematic diagram shall be withdrawn according to the approved NPP procedure of putting equipment out for repair upon the request of NPP Chief Engineer.

#### At the same time, in any mode, the power grid shall provide NPP with power supply required for emergency cool down of the Unit.

#### 5.1.7.7 To eliminate the defects at the operating Unit it is allowed:

1) to withdraw from operation not more than one channel of multi-channel protection or interlock part of ECCS protections shaping system;

2) withdrawal of one ASS set from operation.

The specified withdrawal from operation without preliminary checking of the other channels is allowed for the periods defined in Table 5.1.3.1 observing the safety Unit operation limits and conditions.

5.1.7.8 In case of failures in SS protection and interlock circuits of the type “false activation”, related to safety or activating the equipment which under effect of this event takes a unique position corresponding to protection activation, and is not able to change this position, testing of three other SS channels is not required.

#### 5.1.7.9 In case of defect in CSS related to PT of one channel of the multi-channel protection, PT of which is located in the containment, it is allowed to eliminate the defect during the first unscheduled shutdown or SPM, provided that measuring channel changeover to the actuated condition is ensured as well as daily check of this protection in order to record occurrence of new defects or failures in other channels of the multi-channel protection. Upon detection of the a.m., the protection shall be considered as faulty.

**5.2 The main methods and rules of safety Unit operation at the energy level of power**

#### 5.2.1 At the Unit operation at the energy level of power the safety Unit operation limits and conditions shall be observed as specified in sections 3.3 and 5.1.

#### If the safe operation limits and conditions can not be observed, the Unit shall be shutdown to reveal the reasons and elimination of malfunctions.

#### At disturbances of the normal operation and accidents, the actions of the operative personnel are defined by sections 8 and 9.6.

#### 5.2.2 At exceeding the permissible deviations of the primary and secondary circuit parameters (see section 3.2) in the steady states and upon completion of the transient processes, provide for recovery of the nominal parameter values including also the way of the reactor power decreasing at the maximally permissible rate. If it is impossible to restore the parameters to the values within the operational limits, the Unit shall be unloaded and shutdown in the scheduled sequence and RP changed over to “hot” standby until the reasons are revealed and eliminated.

#### 5.2.3 Power of the reactor and turbine-generator shall be maintained in compliance with the operations schedule at the level permissible for the reactor.

#### The Unit power shall be maintained and varied using APC operating jointly with EPCS of the turbine. The automated coordination of APC and EPCS operation modes shall be provided.

#### It is allowed to maintain and change power using the remote control in compliance with the requirements of this document sections and the operating instructions of the equipment. It is allowed to ascend the reactor power using the remote control at functioning of the main automatic controllers of the Unit.

#### At transferring the turbine to HPCS, any scheduled power variations are forbidden.

#### 5.2.4 The permissible rates of the reactor power variation at the normal operation are specified in Table 3.2.1.6.1.

#### 5.2.5 At changing the reactor power, keep the CPS CR control group in the optimal position as per the schedule of Appendix E, providing for the optimal power-flux field by correction of the current boric acid concentration in the primary circuit.

#### 5.2.6 At the defined reactor power variation, timely switchover NFME settings.

#### EP setpoints shall be set by the neutron power level within operating range for each NFME channel as per the formula:

Ру = Рт + d, % Nnom

where Ру – setpoint value for EP activation;

Рт – current neutron power reading in NFME channel;

d – margin up to EP activation equal to 7 % Nnom at operation with four loops and 10 % Nnom at operation with three and two loops.

#### NFME operating and startup range detection units shall be set in such a way, that drift of readings during CR control group operation in the process of power variation and at xenon oscillations suppression in the core shall not cause more than 3 % unbalancing of the channels within the equipment set.

#### 5.2.7 In all cases, after EP activation it is necessary to start boric acid injection to the primary circuit. If after stabilizing the temperature and pressure in the primary circuit, boric acid concentration is not lower than the value specified in NPC album for the corresponding temperature, terminate boric acid injection.

#### 5.2.8 If there is not possible to control the Unit in normal way, e.g. in cases of the operative personnel gassing, an attack to MCR, the Unit shall be emergently shutdown.

5.2.9 In normal operation modes, if pressure differential at the sorbent trap does not exceed 0,5 MPa (5 kgf/cm2) and pressure differential at the filter does not exceed 0,4 MPa (4 kgf/cm2), it is forbidden to withdraw from operation SVO-1 facility.

5.2.10 During operation at power, all valves of the emergency gas removal system shall be in the closed position.

5.2.11 During operation at power, simultaneous opening of two successively located valves on YR system lines is forbidden.

5.2.12 The interfacing valves on the air removal pipeline from RCPS off-line circuit are locked. Air removal shall be performed daily at the night shift with the mandatory recording to SSRC operative log-book. The interfacing valves on the air removal pipeline from RCPS off-line circuit may be opened only by SSU directive.

5.2.13 Fast-acting valves on the pipelines of the first stage ECCS passive part (YT) shall be opened, their electric circuits shall be assembled, the interlock for closing of these valves by level decreasing in ECCS hydraulic accumulators shall be activated.

5.2.14 It is forbidden to move the gates of the fast-acting gate valves YT11,12,13,14S001,002 by the electric drive, at pressure differential on the valve gate more than 25 kgf/cm2.

In the process of the reactor plant operation at the primary circuit pressure more than 6,9 MPa (70 kgf/cm2), simultaneous opening of valves on two bypass lines of the ECCS passive part check valves is forbidden.

5.2.15 During actuation of ECCS systems or EFWP, the recirculation cooling systems of ECCS and EFWP premises TL08D015,016, 019,020,014,017,018,021,023-026,035-038,039-042, UV31,32,33,34D001,002,003,004, UV31,32,33,34D009 shall be activated and ambient temperature shall be maintained as (35÷50) °С.

5.2.16 Continuous blow-down of the gas space in the relief tank shall be performed by the design circuit. Hydrogen content in the gas space of the relief tank shall not exceed the rated value (3 % of volume).

5.2.17 During the Unit operation at power, the standby HL steam-lines from AB and BRU-SN to the house-load steam-header shall be constantly heated.

5.2.18 Ingress of oil into the radioactive drain system interceptors shall not be allowed.

#### 5.2.19 During the Unit operation, the following is not allowed in drains treatment system TR and concentrated wastes treatment system ТТ:

1) overfilling of tanks;

2) pressure increasing in the tanks;

3) unsealing of tanks.

#### 5.2.20 At power more than 75 %, APP shall be in operation.

#### 5.2.21 The reductive alkalescent ammonia-potassium water chemistry with boric acid shall be applied in the primary circuit. Permissible hydrogen content shall be provided by maintaining equilibrium ammonia concentration in the primary circuit, quality of which corresponds to the directive requirements.

#### 5.2.22 To all solutions injected to the primary circuit without deaeration during the reactor functioning, hydrazine-hydrate shall be added in the amount providing its double or triple excess relatively to oxygen concentration in these solutions.

#### 5.2.23 Long-term operation with the tripped HPH is allowed. At load variation, SG functioning is allowed at the constant feed water temperature as per Table 5.2.23.1:

Table 5.2.23.1

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Power, % of nom. | 0 | 6 | 30 | 50 | 70 | 80 | 90 | 100 |
| Feed water temperature with activated HPH, °С | 164±4 | 164±4 | 164±4 | 170±5 | 200±5 | 206±5 | 218±5 | 220±5 |
| Feed water temperature with tripped HPH, °С | 164±4 | | | | | | | |

#### 5.2.24 It is forbidden to perform any repair and adjustment works in the circuits of activated protections.

#### 5.2.25 After AFPS activation, its serviceability shall be completely recovered no later than in 72 hours, the pipelines shall be blown-off by dry compressed air.

#### 5.2.26 Scheduled tripping of one of three (four) running RCPS, connection of one RCPS to two (three) running ones.

#### 5.2.26.1 Disconnection of one RCPS.

1) Prior to disconnection of one RCPS, the Unit shall be unloaded up to the reactor power not exceeding the permitted value corresponding to the number of the rest running RCPS as per Table 3.2.1.1.1.

2) After RCPS disconnection, the protection setpoints on power shall be set to the values corresponding to the new level of the reactor power as per item 5.2.6.

3) At each shutdown of RCPS motor, check closing of valves at closed circuit water supply line to RCPS motor by the interlock.

Upon written directive of CEP, it is allowed to disconnect SG loops with non-functioning RCPS by feed water, blow-down water and steam provided that BRU-A valve is transferred to remote control. Water level and quality in the disconnected SG shall be maintained within the established limits.

After RCPS tripping, at the closed valves on the main SVO-1 pipelines ТС60(70,80,90)S001, the valves on bypass line ТС60(70,80,90)S002 shall be opened to reduce temperature stresses in the primary circuit make-up nozzles.

#### 5.2.26.2 Mode of RP operation with incomplete number of loops.

#### If a loop with tripped RCPS is left in “hot” standby, the following conditions shall be met:

1) the reactor power shall not exceed the permissible value as per number of running RCPS;

2) the setpionts are set at NFME within the operating range as per item 5.2.6;

3) the level in the disconnected SG is maintained within +100 mm of the nominal SG level.

SG shall be made-up via the main nozzle from FWP (AFWP).

4) SVO-1 condition is in compliance with sub-item 3) of item 5.2.26.1.

#### 5.2.26.3 Connection of one RCPS to two or three running ones:

1) The reactor power shall be reduced up to the corresponding level (to 20 % or 30 % - respectively) of the nominal one.

2) Condition of the other systems and equipment shall correspond to the requirements of section 5.1.

3) After RCPS connection and the Unit parameters stabilizing, the reactor power may be increased up to the value corresponding to the new number of running RCPS, at the same time, NSSS protections setpoints shall be preset to the values corresponding to the new level of power as per item 5.2.6.

#### 5.2.27 At the scheduled HPH de-activation (activation), the following requirements shall be fulfilled:

1) Prior to HPH de-activation, APC shall be transferred to operation in the mode of maintaining the constant neutron power.

2) HPH de-activation by steam shall be performed in such a way, that HPH body temperature variation rate shall not exceed the permissible value (55 °С/hr).

3) Long-term operation at de-activated HPH is allowed. Feed water temperature at deactivated HPH is not less than 160 °С.

4) HPH activation shall be performed at APC operation in the mode of maintaining the constant neutron power observing the requirements on HPH body temperature variation rate limitation as not more than 55 °С/h.

#### 5.2.28 Scheduled FWP disconnection without taking into account the standby feed water pump shall be performed considering the following requirements:

1) Before disconnection of one FWP, the Unit shall be unloaded up to the reactor power not exceeding 50 % of the nominal one.

2) FWP shutdown shall be performed observing the limits defined by the operating instruction.

#### 5.2.29 Fuel cladding integrity shall be monitored:

1) at the operating reactor – periodic control of the coolant activity;

2) at the shutdown reactor – fuel assembly control using DADS.

#### Scope of FCIM during SPM at the RP shutdown is defined in compliance with the following criteria:

#### 5.2.29.1 If as per FCIM data, there were no leaking FE within the operational fuel loading at the operating reactor, FE FCIM at the shutdown RP during SPM shall not be performed both for spent FA and for those which are left in the core for further operation.

#### 5.2.29.2 If FCIM results at the reactor functioning shows availability of leaking FE within the operational fuel loading, scope of FCIM during SPM at the shutdown RP shall be defined by the total specific activity level of iodine radioactive nuclides.

1) FE FCIM for all FA operated within this fuel loading is mandatory if the following condition is observed: if the average value of specific activity of iodine radionuclide-131 in the primary circuit coolant, specified for the period of less than 3 days at nominal reactor parameters related to its penetration only from non-tight fuel elements - АI-131 was exceeded; АI-131 > 7.4×105 Bq/kg (2.0×10-4 Cu/kg), then it is necessary to perform FE FCIM for all FA operated within this fuel loading.

2) It is allowed not to perform FA FE FCIM during SPM:

- if values of specific iodine-131 and iodine-134 activity in the primary circuit coolant simultaneously did not exceed the level of 1,0×10-6 Cu/kg within all period of the fuel loading operation;

- if during the whole period of fuel load operation a spike-effect is not registered and during the scheduled shutdown of the unit to measure activity of iodine radionuclides in the coolant of the primary circuit did not prove the presence of spike-effect, and if the ratio between average values of specific radionuclide activity of iodine-131 to iodine-134 (А131/А134) was not exceeded more than 5 times. Diagnostics of the spike-effect shall be performed according to methods, described in OI for FCIM.

3) In cases not related to items 1) and 2), spent FA FE FCIM conduction is mandatory.

#### 5.2.30 At the Unit operation at power, the personnel shall:

1) perform monitoring for functioning of the process, electrical equipment, I&C hardware in order to reveal deviations from the assigned modes and to take decisions on their elimination.

2) monitor functioning of the automatic controllers.

3) reveal reasons for protections and interlocks activation, to perform the actions required for bringing the process equipment to the defined condition after protection activation.

4) perform periodical serviceability check of the equipment and systems as per the schedule approved by NPP chief engineer in the scope specified in section 10.2.

5) control water chemistry of the primary circuit coolant, to perform correction, if required.

6) control the secondary circuit water chemistry, to perform correction, if required.

7) monitor radiation situation at NPP, values of average daily and monthly radioactive gas and aerosol releases from NPP vent stacks, activity of discharged purified water and do not exceed the established norms.

8) perform walk-down, inspection, and maintenance of the equipment in the scope and with periodicity defined by the operating instructions for the equipment.

9) perform pressure monitoring in ISC at least once per shift with recording the results in the operative log-book.

10) maintain the operational resources of media and materials of the required quality providing for the Unit operation.

11) perform AWT and UDP filters rinsing, back-washing and regeneration as per their operating instructions.

12) monitor separation of low pressure and high pressure pipelines of the primary and secondary circuits every shift at the accessible places and by alarm as per the operating instruction for the primary circuit.

13) press EP, PP key immediately in case of availability of EP, PP activation criteria as per readings of the devices, and absence of the relevant source signal and EP, PP functioning.

14) upon occurrence of conditions causing ECCS activation, and failure of the automated ECCS mechanisms startup, the operator shall activate them manually.

15) withdraw the equipment for maintenance, prepare workplaces or repair activities, accept workplaces after repair completion, check and put the repaired equipment to operation or standby.

16) at withdrawal the individual equipment of intermediate service water cooling systems to repair, take preventive measures to avoid failure of PT, ACC, boron-meters, radiation monitoring sensors due to temperature increasing.

17) perform continuous monitoring for FE cladding integrity using automated process radiation monitoring system (APRMS) by the specific total gamma-activity of the primary circuit coolant.

18) perform periodic control for isotopic content of the primary and secondary circuit media by methods of sample radiochemical analysis.

19) control leakages from the primary circuit to the secondary one by reference radioactive nuclides at least once a week.

When the measured leakage value is within the range from 0,5 kg/hr to 4,0 kg/hr, the leakage shall be controlled at least once a day.

20) Monitor temperature of RP equipment and structures.

21) Monitor liquid availability in the hydraulic snubber pots.

Position of the hydraulic snubber pistons shall be controlled every shift. The distance between the hydraulic snubber piston and the cylinder end face shall not be les than 20 mm.

22) Control core peaking factor Кvi, FA peaking factor Кqмакс., axial offset (see Appendix E).

23) Control position of individual CPS CR in the control group and perform their alignment by height not allowing misalignment to be more than 60 mm.

Control position of individual CPS CR from non-control groups at USS. At sinking of individual CPS CR, lift them to USS individually. Perform CPS drives reciprocation no less than once a month.

24) Control sufficiency of CPS drive cooling due to ventilation system TL13 operation.

25) Control quality indices of steam and water PRZ phases as per Table F.13 in Appendix F.

26) During operation at power, leakages through check valves on ECCS lines shall be periodically controlled.

27) After each mode of water supply to PRZ injection nozzle with temperature different from PRZ water temperature to more than 90 °С, during next shutdown it is required to check injection nozzle elements and PRZ body elements at the nozzle, as well as injection line sections within the range of coolant effect with temperature difference more than 90 °С, accompanied by visual inspection, dye penetrant flaw detection and UT.

28) In the process of operation, the regular monitoring for the sealing liner anticorrosive coat condition shall be performed (if any traces of damaging are revealed, it shall be restored). If, by the inspection results, any deviations from the established requirements are revealed, the decision on further operation shall be taken by the operating organization as per the established procedure.

Quality control of the primary circuit coolant, primary make-up water, fuel pool water, PRZ water and steam media, solution quality in the emergency boric acid storage tanks, concentrated boric acid solution, alkaline solution of the spray system and solution in ECCS HA shall be performed in the scope and with periodicity specified in Appendix F.

In the process of operation, the residual life of RP equipment elements shall be continuously monitored using subsystem ARLCS in MCDS system.

5.2.31 Water chemistry of the primary and secondary circuits during the Unit operation at power

#### 5.2.31.1 Water chemistry of the primary and secondary circuits shall be provided as per the requirements of Appendix F.

5.2.31.2 In case of the steam-generator feed and make-up water quality indices deviation from the rated ones, as specified in Tables F.15, F.16, F.18 and F.19of Appendix F, the limits are established to the Unit operation.

5.2.31.3 Degree of the turbine condensate purification shall provide for non-exceeding of the specific condensate conductivity indices at the outlet of each MBF with value 0,15 µCm/cm. At the same time, connection of UDP filters as per the operating circuit after regeneration or idling at value of this index more than 0,15 µCm/cm is not allowed.

5.2.31.4 Values of UDP (CF, MBF, ionite filters-traps) process parameters shall be within the limits stipulated by the manufacturing documentation (passports) and operating instructions.

5.2.31.5 At observation of the established steam-generator feed and make-up water quality norms, it is allowed complete or partial tripping of the condensate polishing.

5.2.32 To maintain SG water chemistry, the following shall be provided:

1) Continuous blow-down of each steam-generator from «salt» section in cold end face at flow-rate up to 1 % (up to 15 t/hr) of steam-capacity at constant flow-rate monitoring.

2) Periodical blow-down, if required – blow-down from all steam-generators at total capacity 60 t/hr, at the same time, one steam-generator shall provide possibility to blow-down maximally up to 45 t/h.

Periodical blow-down of the steam-generators shall be performed by united blow-down line (headers chambers and steam-generator vessel nipples).

Periodicity of actuation and duration of periodical blow-down shall be defined by the blow-down schedule after testing joint operation of blow-down systems and blow-down water treatment systems at the stage of commissioning.

At transient and starting operation modes of the reactor plant, continuous steam-generator blow-down flow-rate shall be maintained at the maximal possible level until rated indices of operating medium quality are reached.

At deviation of blow-down water quality in the individual steam-generator from requirements of water chemistry norms, blow-down from «salt» section of this steam-generator shall be increased maximally up to 45 t/h.

Injection of the corrective chemical additions in the required amount shall be provided as well as effective feed-water deaeration. UDP is started up.

5.2.33 At any operation mode of the Unit, alarm video-frame shall be open at each workstation /ERC, ETC and SSU / and timely receiving and confirmation of process alarm signals shall be provided at performing activities in compliance with the operating instructions.

5.2.34 All CPS CR , except for CPS CR of the working group (position of working group shall be maintained according to Appendix E, Fig, E2) shall be at ULLS (at unavailability of APP signal). Upon APP signal receiving, APP group CPS CR shall drop, after that they shall be extracted to ULS within the time not more than 3 hours.

# 6 THE UNIT SHUTDOWN AND COOL-DOWN

**6.1 Safety operation conditions at the Unit shutdown and cool-down**

**6.1.1 Safety operation conditions at the Unit change over to "hot" condition**

1) The Unit shutdown shall be performed using I&C TC and ACS at APC functioning in the mode of secondary circuit pressure maintaining.

It is allowed to reduce the reactor power by CPS CR operating group insertion, if APC failed.

2) Rate of the reactor power reducing shall not exceed the permitted value in compliance with Table 3.2.1.6.1.

3) At the scheduled shutdown of the Unit to “hot” condition, the reactor sub-criticality shall be provided by way of increasing boric acid content in the primary circuit coolant up to the value not less than minimally-permissible for “hot” standby at this lifetime moment, defined as per “Neutron-Physics Characteristics Album For The Current Fuel Loading”.

4) At the scheduled shutdown of the Unit to “cold” condition, the reactor sub-criticality shall be provided by way of increasing boric acid content in the primary circuit coolant up to the value 16÷18 g/dm3.

5) At the Unit shutdown for scheduled repair and the reactor refueling, the reactor sub-criticality shall be provided by way of increasing boric acid content in the primary circuit coolant up to steady concentration 16 – 20 g/dm3.

6) Unconfined space is prepared in the coolant storage system tanks TD11,12,13B001 (at least 240 m3) to intake discharged primary circuit water.

7) Prior to the Unit shutdown for the period more than three days, to preserve condensate-feeding path, it is necessary to perform the secondary circuit operating media treatment by hydrazine-hydrate within 24÷48 hours maintaining hydrazine concentration in feed water not lower than 0.5 mg/kg. Cation-exchange filters and MBF of turbine condensate demineralizing system can be tripped at the moment of staring the increased hydrazine-hydrate dosing. In this period, the steam-generators shall be blown-down by turns at the maximally possible flow-rate. At the same time, ammonia feeding is not performed.

During the specified period of operating media treatment it is allowed to increase pH value (at 25 С) in feed water up to 9,8, and in blow-down water – up to 9,4.

During hot standbys of the Unit for the period not more than three days, the operating media treatment with hydrazine-hydrate shall not be conducted.

**6.1.2 Safety operation conditions in the process of the reactor plant cool-down**

#### 6.1.2.1 During cool-down, the reactor plant equipment shall meet the following requirements:

1) Prior cool-down starting, boric acid concentration shall be increased up to the values defined in compliance with in compliance with sub-items 6.1.1.4-5);

2) All low pressure pipelines of the auxiliary systems shall be disconnected from the high pressure pipelines by means of the interfacing valves of these systems except for:

a) at the coolant temperature in the hot legs of the reactor not more than 130 °С, it is allowed to activate TH system;

b) upon reaching the primary circuit pressure 20 kgf/cm2, the nitrogen supply line shall be connected for the time of nitrogen blanket creation in PRZ;

c) at the primary circuit coolant temperature less than 150 °С, the emergency reactor and SG blow-off are united.

3) There is steam cushion or nitrogen blanket in PRZ, PRZ level is 11200 mm (level calculation from the bottom internal generatrix of PRZ shell), PRZ PSD are ready for.

4) At least two RCPS are in operation, the others are ready for operation, cooling and sealing water is supplied to them.

It is allowed to trip RCPS, terminate forced circulation through the reactor core for the time of the scheduled cool-down system connection to the primary circuit.

5) Filters of primary circuit water reentrant treatment system (SVO-1) are activated at the loops with running RCPSs.

It is allowed to withdraw SVO-1 from operation, at the loops with running RCPSs.

At withdrawn SVO-1 legs, to provide cool-down of legs in parallel to primary circuit cool-down, flow-rate via the legs is performed by bypass - TC60(70,80,90)S002,004,005,006 are open.

6) The level in each SG is (3700÷3800) mm. SG SV, BRU-A, BRU-K, BRU-SN are ready for operation.

7) In cool-down process, PRZ cool-down regulator shall maintain water temperature difference in PRZ and the primary circuit coolant as less than 55 °С.

8) RP cool-down rate shall not exceed the design permitted value 30 °С per hour.

9) Metal temperature difference between upper and lower PRZ vessel parts is: PRZ – less than 85 °С, SG – less than 40 °С.

10) Difference between feed water temperature and SG boiler water temperature shall not exceed the permissible value 120 °С. Feed water shall be continuously supplied to SG from AFWP using the startup-and shutdown regulators in the automated mode.

11) If there is no nitrogen blanket in PRZ, MCC cool-down shall be performed so, that PRZ water temperature shall exceed water temperature in MCC to (15÷70) °С.

12) Within the whole cool-down process the upper unit equipment and the reactor cavity cooling system TL03, TL13 shall be functioning.

13) At the primary circuit coolant temperature less than 200°С, functioning of more than three RCPS is not allowed.

14) At availability of nitrogen blanket in PRZ, solute gas concentration in the primary circuit coolant shall not exceed the permissible value due to conditions for circulation termination in RCPS off-line circuit (20 mg/kg).

Gas blow-off from RCPS off-line circuit shall be periodically performed.

15) Upon reaching MCC water temperature value as (60÷70)°С, condition of the systems and equipment shall at least meet the requirements specified in item 4.1.1 for “cold” condition of the Unit.

1. Perform thorough gas removal from the primary circuit and the coolant degassing. At the same time, in order to avoid explosive hydrogen concentrations in the primary circuit, provide the following in “cold” condition mode:

a) Simultaneous injection of the boric acid and the Unit cool-down is not allowed.

b) after pressure drop and level decreasing in the reactor up to the main joint, it is required to provide for UU dismantling within not more than one day or disassembling of three central CPS drives with the displacement unit withdrawal, and arrange nitrogen blow-down by the following path: nitrogen system – reactor – CPS drive housings – CH with hydrogen concentration monitoring in CH air;

c) if long-term outage of the reactor in the assembled state is required at reduced water level in the reactor – upper constituent of the cold nozzles, the reactor and SG ventilation shall be arranged by the following path: nitrogen system – hot headers of each SG air vents - reactor – three CPS drive housings - CH, with hydrogen concentration monitoring in CH air.

1. In cool-down process do not allow pressure increasing over the value shown in the diagram of Appendix H.

**6.1.3 Safety Unit operation conditions in “shutdown for repair” condition**

#### 6.1.3.1 The reactor plant systems and equipment condition:

1) The reactor is sub-critical. At the Unit shutdown for the scheduled repair and the reactor refueling, the reactor sub-criticality shall be provided by increasing primary circuit boric acid content up to the value not less than 16 g/dm3. By taking organizational-and-technical measures, exclude ingress of media with boric acid concentration less than 16 g/dm3 to the core(as per OI for RP).

2) The primary circuit is unsealed, MCC pressure is atmospheric, the temperature at the reactor top is not more than 70 °С.

3) The repair of valves on the pipelines connected to the primary circuit (the first one counting from the side of the primary circuit), nozzles of which at MCP are in-cut below the upper constituent of «cold» MCP legs, shall be performed in conditions of complete FA unloading from the core.

4) During repair activities requiring coolant level decreasing to more than 300 mm below RMJ elevation, but not lower than the upper constituent of the reactor cold nozzles, not earlier than in 138 hours after the reactor shutdown, arrange coolant circulation at flow-rate (350÷400) m3/hr by the “repair circuit”: water supply to the reactor at the core top from TH system pump, water removal - via “cold” leg of MCP loop providing for temperature monitoring and non-exceeding over 70 °С at the inlet to heat-exchanger TH10,20,30,40В003. Observe the measures on non-admission of fire-risky and explosive hydrogen concentration buildup (see item 6.1.2.1 sub-item 16).

5) During internal inspection of PRZ, ECCS HA and SG headers, it is required to blow-down (ventilate) thoroughly the pipelines and tanks by air.

6) After removing the reactor upper unit and PTU, perform neutron flux density monitoring using MSR detecting units mounted to the reactor cavity baffle channels and NFME detecting units.

7) Provide for automated coolant level control in the reactor with recording at MCR – minimal reactor level value is 600±50 mm over the axis of the reactor «cold» nozzles.

While recharging fuel assemblies, the level of water in compartments of the spent fuel and refueling pool should be maintained at least at 3000 mm from the top of the transported irradiated fuel assembly. It corresponds to the level of min. +21,000 m (-0,1 m).

#### 6.1.3.2 Condition of the main schematic diagram and the Unit auxiliary power supply circuit corresponds to the requirements subjected in "cold" condition " mode (see item 4.1.1.2).:

#### 6.1.3.3 EPSS and SS condition shall meet the requirements subjected in “cold” condition mode (see items 4.1.1.3, 4.1.1.4).

#### It is allowed to terminate forced circulation through the reactor core for the period of making switchovers to changeover cool-down from one channel of residual heat removal system (TH) to the other one. During this period, monitor the temperature at the reactor top, which shall not exceed 80 °С. The permissible time for circulation termination is not more than 2,5 hours at the coolant level not lower than upper constituents of the reactor cold nozzles.

It is allowed to terminate FP cool-down for the time of making switchovers at the fuel pool chilling system but not more than three hours with constant BAS temperature monitoring in FP, which shall not exceed 70 °С.

If its necessary to correct SFP WC in case there are refueling operations in SFP, it is allowed to reduce SFP level to the level not lower than +19.0 m for the time required to correct WC in SFP, max. 24 hours, when SFP cooling system TH18(28,38,48) is operating in the standard mode and in case BAS temperature in SFP is constantly controlled, which shall not exceed 50 °С

#### At complete fuel unloading from the reactor, the time of forced circulation termination is not restricted.

6.1.3.4 One SS channel can be withdrawn to maintenance for the time defined by this specification.

#### 6.1.3.5 Premises where the equipment of serviceable SS channels is located are closed to avoid access of the unauthorized persons.

#### 6.1.3.6 The following equipment units shall be operating in order to remove residual heat from the active core and FP:

#### - one channel of the low pressure subsystem TH10(20,40) (with the operating pump TH10(20,40)D001 or TH18(28,48)D001) – to remove residual heat from the active core according to the scheme of planned cooldown of the primary circuit and one channel of the low pressure subsystem TH10(20,30,40) (with the operating pump TH18(28,38,48)D001 – to cool the fuel pool water.

#### - one channel of the low pressure subsystem TH10(20,40) with the standby pump TH10(20,40)D001 or TH18(28,48)D001 should be ready for use, connected to the primary circuit according to the scheme of the planned cooldown.

#### - in case of the complete unloading of the active core, heat removal form FP shall be performed via two channels of TH18(28,38,48) system (in case one channel is insufficient for operation).

**6.1.4 Responsibilities of the personnel when performing the operations on the Unit shutdown and cool-down**

#### Responsibilities of the personnel in each specific RP condition corresponds to the requirements specified in Chapter 4. In the process of the scheduled Unit shutdown and cool-down it is required also to perform all periodic tests and checks of the equipment as per section 10.2.

#### After repair or idling more than 10 days, the following shall be checked:

1) defect-free condition of thermal insulation;

2) condition of thermal displacement indicators;

3) serviceability and absence of extraneous objects in RCPS, SG supports;

4) free thermal displacements of the equipment and pipelines;

5) readings of the temperature displacement measuring gauges and their correspondence to the actual primary circuit temperature;

6) condition of valves on the sampling lines;

7) condition of drainages and air vents;

8) condition of the thermal control devices.

#### The comments revealed during inspection shall be eliminated.

**6.2 Sequence of actions, rules and main methods of performing the operations on the Unit shutdown and cool-down**

**6.2.1 Scheduled Unit changeover from “operation at power” condition to “hot” condition**

1) Prior the Unit shutdown for the period more than three days, to preserve condensate-feeding path, it is required to perform primary circuit operating medium treatment with hydrazine-hydrate within (24÷48) days, at maintaining hydrazine concentration in feed-water not less than 0.5 mg/dm3. Cation-exchange filters and mixed bed filters of the turbine condensate demineralization system shall be tripped at the moment of starting increased hydrazine-hydrate dosing. In this period, steam-generators shall be blown-down by-turns at maximally possible flow-rate. Ammonia dosing shall not be performed.

During a.m. operating medium treatment period, it is allowed to increase pH value (at 25 С) in feed-water up to value 9,8, and in blow-down water – up to 9,6.

At short-time shutdowns of the Unit for the period less than three days, operating medium may not be treated with hydrazine hydrate.

2) Permit for the scheduled Unit shutdown shall be given by CEP after obtaining the relevant permission form the dispatcher control centers.

3) Operations on the Unit unloading and its shutdown shall be performed by the operative personnel by the written directive of SSU.

4) The Unit power decreasing shall be performed by changing the turbine-generator power setting at EPCS panel at the rate not more than 3 % Nnom per minute.

5) Maintain CPS CR operating group in the control zone by periodic boric acid solution injection to the primary circuit in compliance with item Е.5.2.1.1. and figure Е.2 of Appendix Е.

6) Steam pressure in SG is within permitted limits and maintained by joint operation of APC and EPCS.

7) At TG power 600÷700 MW, open HPH bypasses, then trip HPH by feed-water and by steam.

8) Check automatic fulfillment of operation on the secondary circuit systems and equipment shutdown:

- trip of the second II stage CP (one II stage CP is in operation);

- trip of the second I stage CP (one I stage CP is in operation);

- trip of FWP;

- BRU-SN actuation and closing the gate-valve at III sampling steam-line.

9) The last FWP shall be tripped after AFWP activation at power not more than 5 % Nnom.

10) The turbine unloading and tripping shall be performed observing the requirements of OI for the turbine.

11) After turbine trip, trip APC and perform further power decreasing by boric acid injection to the primary circuit.After reactor power reducing to less than 1 % Nnom, RP is in condition "at MCL ".

12) By further boric acid injection to the primary circuit changeover the reactor to «hot» condition.

13) After creating the required steady boric acid concentration in the primary circuit coolant, equalize boric acid concentrations in PRZ and primary circuit, leave at least two RCPS in operation and move-down all CPS CR to LLLS. Check CPS CR drop time. CPS CR drop time shall be within 1,2-4 sec.

14) Take measures on preventing distillate ingress to the primary circuit as per the requirements of "Operating instruction of the primary circuit.

**6.2.2 Scheduled Unit changeover from “hot” condition to “cold” condition**

#### 6.2.2.1 Cool-down of the Unit.

1) It is not allowed to cool-down the reactor, if boric acid concentration in the primary circuit coolant is less than 16÷18 g/dm3 value defined in compliance with items 6.1.1 4) and 5).

Provide for BAS concentration balancing in PRZ, MCC and makeup deaerator.

2) During cool-down process, control non-exceeding the limit values of the systems and equipment parameters and characteristics specified in section 3 and Appendix B.

3) During the whole cool-down process, all RCPS auxiliary systems shall be in operation.

4) At scheduled RP cool-down, all ventilation systems, air conditioning systems and recirculation air cooling systems shall be kept in operation. The upper unit equipment and the reactor cavity cooling system shall be kept in operation.

5) Fill PRZ up to 11200 mm level (level calculation from the bottom internal generatrix of PRZ shell) and maintain it within all cool-down period.

6) Prior to cooling-down, fill-in the steam-generators up to maximally possible controlled level 3700 - 3800 mm.

Further, maintain this level during all cool-down period.

7) Trip the primary circuit pressure regulator, actuate PRZ cool-down regulator and by injecting coolant from RCPS head, start PRZ cool-down. Upon reaching temperature difference in PRZ and the primary coolant temperature as 55 °С, start steam relief from the steam-generators via BRU-K to the turbine condenser in the amount providing the reactor plant coolant cool-down rate not more than 30 °С/h.

Make-up the steam-generators from the deaerator. Feed water temperature shall be smoothly decreasing from 160 °С to 40 °С.

8) At the primary circuit coolant temperature less than 150 °С, unite the emergency blow-off of the reactor and SG.

9) In RP cool-down process, the minimally-possible temperature differential shall be

provided at the primary circuit make-up nozzles and the primary circuit make-up and blow-down system operation shall be arranged with the maximally-possible capacity (60 t/hr) at maintaining the required PRZ level.

10) At the primary circuit pressure (8,8÷9,8) MPa ((90÷100) kgf/cm2), disconnect ECCS HA from the reactor. To avoid «cold» over-pressurization of the primary circuit, disassemble the power supply circuits of the stop valves:

* + on the pipelines of the first stage ECCS passive part YT11,12,13,14S001,002, lock, place warning placards;
  + on the pipelines of the second stage ECCS passive part TH16,17,26,27,36,37,46,47S001,002, lock, place warning placards.

11) Upon reaching the pressure above the core 1,96 MPa (20 kgf/cm2) (PRZ temperature – 210 °С, primary circuit temperature - 155 °С), open the valves on PRZ nitrogen supply line.

Nitrogen temperature - (20÷60) °С. Volume of the supplied nitrogen modified for pressure 20 kgf/cm2, is 4 m3, supply time is 4 hours.

12) Further PRZ cool down shall be performed at rate 30 °С/hr without maintaining the temperature difference between PRZ and the primary coolant.

If there is no nitrogen blanket in PRZ, PRZ cooling-down shall be performed so that BAS temperature in PRZ exceeds BAS temperature in MCP at least to 15 °С, but not more than 70°С.

13) In RP cool-down process, perform alternate periodic blow-down of all SG with the maximum blow-down flow-rate. Perform each loop SG blow-down from the moment of starting cool-down till reaching the primary circuit temperature about 100 °С.

14) Perform primary circuit coolant cool-down using the following algorithm:

* 1-st stage of RP cooldown: RP cooldown from 280 0С to 130 0С shall be performed by steam discharge from steam-generators through BRU-SN to auxiliary header and through BRU-K to turbine condenser (when vacuum breaking in condenser, through BRU-А to the atmosphere);
* 2-nd stage of RP cooldown: RP cooldown from 130 0С to 70 0С at two operating RCPS and primary circuit pressure of 1,47 – 1,8 MPa (15 – 18,4 kgf/cm2) shall be performed by operation of a single pump of ТН10,20,40 system with the pump capacity not less than 700 m3/h and by steam discharge from steam-generators through BRU-К to condenser. Temperature difference between the primary circuit coolant and water delivered from circuit ТН10,20,40, shall make up not greater than 30 0С.

Temperature difference of water in the connected standby channel ТН10,20,40 (standby channel is used for the case of failure of operating channel in the planned cooldown mode) and in the primary circuit shall ne exceed 60 0С.

Cooldown stage with steam discharge from SG to turbine condensers at RCPS being operated finishes at the temperature level in the secondary circuit 60 -70 0С.

Further SG cooldown shall be implemented on account of multiple water exchange.

15) Residual heat removal from the reactor core after RCPS trip at coolant temperature at the outlet from the reactor core 70 0С shall be performed:

- by operation of a single pump of ТН10,20,40 system with the pump capacity not less than 700 m3/h maintaining the pressure in the primary circuit 1,0 – 1,5 MPa;

- by operation of two channels of ТН10,20,40 system at atmospheric pressure in the primary circuit with the flowrate of water delivered to the primary circuit – not less than 350 m3/h from each of the pumps at concurrently open recirculation line of pumps «towards oneself» through valves TH10,20,40S010 while observing the following conditions:

а) total pump output measured on the metering orifice TH10(20,40)F001 on the head of the pump shall be not less than 700 m3/h;

b) when so doing the flowrate to the primary circuit and to the recirculation line is distributed approximately equally;

c) required rate of the core cooldown shall be provided by controllers TH10,20,40S007,008;

d) the mode of reactor core cooldown shall be monitored using standard instruments of thermal monitoring of ТН10,20,40 systems.

16) During operation at nitrogen blanket, monitor solute gas concentration in the primary circuit coolant. Nitrogen concentration shall not exceed the permissible value of 20 mg/kg (due to conditions for circulation termination in RCPS off-line circuit). Continuous gas blow-off from RCPS off-line circuit shall be performed.

17) At the primary circuit temperature less than 130 °С, disassemble electric circuits of pumps TH15,25,35,45, TW10,20,30,40, RS10,20,30,40 and PRZ TEH.

18) Trip functioning RCPS upon reaching water temperature (60÷70) °С in MCC at the reactor core top.

In the mode of the core residual heat removal the TH system is in operation, stabilize coolant temperature at FA outlet as not more than 70°С.

19) After tripping all RCPS, further cool-down shall be performed taking into consideration the following requirements:

a) PRZ cool-down shall be performed by water supply from the primary circuit make-up system up to temperature (60÷70) °С;

b) pressure in 1st stage ECCS HA shall be decreased up to the permitted value of 3,4 MPa (35 kgf/cm2).

It is allowed not to decrease pressure in ECCS HA, at the same time fast-acting gate valves YT11,12,13,14S001,002 shall be closed, electric circuits shall be disassembled, and the gate valves locked, drainages between gate valves shall be opened.

20) It is allowed to decrease SG level up to the nominal value or its draining after the primary and secondary circuits cool-down up to (60÷70) °С.

21) The required primary circuit water quality in the steady state shall be provided at RP cool-down by injecting the required chemicals to make-up pumps suction. The secondary circuit water quality also shall be provided.

In the process of the scheduled Unit shutdown, the personnel shall provide for the equipment preservation in compliance to 6.1.1.7.

22) During cool-down process, do not allow pressure increasing over the value specified in the diagram of Appendix H.

#### 6.2.2.2. At the stage of the Unit cool-down as per the approved programs, perform the equipment testing and checks in the scope specified in section 10.2.

**6.2.3 Preservation of the steam-generators**

6.2.3.1 In the process of operation, to perform refueling, technical witnessing and repair of the equipment, short-term (up to 15 days) and long-term (from 15 days to 3 months) shutdowns of the Unit for SPM are possible.

#### 6.2.3.2 Depending on shutdown duration, NPP personnel shall develop a specific preservation mode for each SG in compliance to the process chart of works in SPM period at the shutdown Unit.

#### 6.2.3.3 SG preservation during the Unit shutdown shall be documented and recorded in the operative log-books at MCR.

#### 6.2.3.4 SG preservation during short-term shutdowns of the Unit (up to 15 days)

#### 6.2.3.4.1 Leave steam-generators, for which manhole unsealing for the shutdown period is not envisaged, filled with feed water up to 3700-3800 mm level.

#### 6.2.3.4.2 Preservation of SG, for which manhole unsealing is envisaged in order to perform the works inside, shall be carried out by «dry conservation» mode in the following way:

- after the reactor pant cool-down completion at SG vessel bottom temperature 80 °С and BRU-A valve opened, drain SG by the secondary circuit;

- drain SG due to heated metal warm.

Air supply by SG blow-down system shall provide more effective moisture removal outside SG than in the case, when only BRU-A opens.

#### 6.2.3.4.3 Repeated SG filling, after conduction of works inside it, shall be performed by chemically-demineralized water with chloride-ion content not more than 50 µg/kg.

#### 6.2.3.5 SG preservation in the period of long-term shutdowns of the Unit

#### 6.2.3.5.1 SG preservation for the period of long-term shutdowns of the Unit shall be performed by one of the following ways:

- «dry preservation»;

- «wet preservation».

#### 6.2.3.5.2 If it is required to perform technical witnessing or repair works inside SG, SG shall be preserved by «dry preservation» method, as per the requirements of item 6.2.3.4.

#### 6.2.3.5.3 If it is impossible to perform «dry preservation», perform SG dry-out using hot air supplied by radiator to the SG bottom part via manholes.

#### 6.2.3.5.4 At least once a week perform monitoring of relative air humidity in SG, which shall not exceed 60 %.

#### 6.2.3.5.5 At relative air humidity increasing up to 70 %, duration of SG preservation shall not exceed 1 month. To decrease relative air humidity up to the value not more than 60 %, it is required to dry-out SG repeatedly by hot air, as per item 6.2.5.5.2.

#### 6.2.3.5.6 If SG unsealing by the secondary circuit is not envisaged, perform SG «wet preservation», for this purpose fill it with demineralized water including steam header with chloride-ion contents not more than 50 µg/kg and ammonia addition to it up to рН value 10,5-11,0.

#### 6.2.3.6 The information on SG preservation shall be recorded in the operative log-books at MCR and in the chemical control log-books. The report (Act) on SG preservation shall be drawn up.

**6.2.4 Chemical cleanup of the steam-generators**

The permissible value of sediments on the heat-exchanging tubes shall not exceed 100 g/m2 at any of the controlled areas of the tube bundle.

#### Based on the fact that the equipment of the condensate-feeding path does not contain copper-bearing structures and sediments on SG heat-exchanging tubes will mostly consist of ferrous compounds, SG chemical cleanup shall be performed during RP cool-down.

#### During RP cool-down, prior to the Unit shutdown for SPM, SG chemical cleanup shall be performed at the side of the secondary circuit in order to remove the corrosion sediments from heat-exchanging tubes, upon reaching specific contamination 100 g/m2 at any controlled area.

#### During SG chemical cleanup at RP cool-down, up to 80-100 g/m2 of corrosion sediments shall be removed. Periodicity of each SG cleanup shall be defined by results of SG internal surface corrosion tests, presented by required protocols, at least every 4 years.

#### Cleanup solution composition shall be specified based on the results of the secondary circuit SG internal surface condition control to be performed during SPM preceding the chemical cleanup. At the same time, the specific contamination and chemical composition of sediments shall be evaluated, which shall be considered during calculation of chemicals quantity for the cleanup solution.

#### Chemical cleanup effectiveness (completeness of sediments removal) shall be evaluated by way of comparing the initial specific contamination of the heat-exchanging tubes before cleanup, defined by SG inspection results during previous SPM, with the residual specific contamination of the heat-exchanging tubes defined by SG inspection results after cleanup.

#### At the same time, by the cleanup solution analysis, the quantity of corrosion sediments removed from the secondary circuit SG heat-exchanging tubes as the result of cleanup shall be defined .

**6.2.5 Sequence of actions, rules and the main methods of performing the operations on the Unit changeover from “cold” condition to “shutdown for repair” condition**

#### 6.2.5.1 MCC unsealing.

1) Decrease primary circuit pressure up to atmospheric one at the coolant temperature at the reactor top as (60÷70) С.

2) Drain off primary circuit coolant up to the level below RMJ to (200÷300) mm, but not lower than upper constituent of the reactor cold nozzles.

3) Prior to MCC unsealing, disconnect ribbon cables from CPS drives, ICDS, dismantle removable parts of CPS drive cooling air-pipe insulation units, as well as the wiring box and the reactor air vent.

4) At MCC unsealing, to perform repair activities at the primary circuit equipment requiring coolant level decreasing to more than 300 mm below RMJ elevation, without reactor disassembling or with its disassembling, except for fulfillment of requirements in sub-item 1, not earlier than in 138 hours after the reactor shutdown, coolant circulation at flow-rate 350-400 m3/hr shall be arranged by the “repair circuit”: water supply to the reactor at the core top from TH system pump, water removal - via “cold” leg of MCP loop, and water draining to MCP shall be performed up to the level not lower than the upper constituent of the inlet (“cold”) reactor nozzles. At the same time, the measures shall be observed preventing buildup of the explosive hydrogen concentrations (see item 6.2.3.1, sub-item 25).

5) It is forbidden to unseal RP without preliminary multiple radioactive gas removal from MCC and at non-functioning gas treatment system.

6) Prior the reactor unsealing, at least triple cycle of decreasing/increasing the level in the primary circuit shall be performed to ensure degassing of the coolant.

7) removal of reactor head is allowed in the following cases:

- 72 hours after reactor shutdown under the provision that two channels of ТН10,20,40 system are operating and the third channel of ТН10,20,40 system of heat removal from reactor is standby;

- 138 hours after reactor shutdown under the provision that one channel of ТН10,20,40 system is operating and the second channel of ТН10,20,40 system of heat removal from reactor is standby.

# 7 REFUELING

**7.1 Incoming inspection and fresh FA storage**

#### 7.1.1 One hundred percent recording of nuclear fuel and its displacement within NPP shall be provided.

#### 7.1.2 Acceptance, initial incoming inspection and storage of TPS with fresh FA, CPS AR and BAR shall be arranged in the individual building of FFS prior to their transportation to NPP reactor building.

#### 7.1.3 TPS with fresh fuel shall be arranged horizontally at the assigned places, by sets (16 pieces per set, not more). The distance between sets shall be at least 2,5 m. The packs shall be arranged by height not more than in four rows.

#### 7.1.4 The initial incoming inspection includes:

#### - check of the shipping documentation completeness;

#### - acceptance of TPS by quantity;

#### - external inspection of TPS (check for integrity of seals, availability of labels and accompanying signs, condition of the outer surfaces of the packs);

#### - check of the indicator readings, to control degree of bumps and shakings to which TPS and FA have been subjected during transportation to NPP Site.

#### 7.1.5 Fresh fuel in the amount (~ 60 FA) required for the upcoming refueling shall be stored in FFS located in the reactor building.

#### 7.1.6 Fresh FA shall be withdrawn from TPS at + 21,5 m elevation of the central hall, then they shall be placed to the FFS jig at the reactor building, where the final incoming inspection shall be performed. After the jig, FA shall be placed to the bottles-cells of the reactor building FFS racks.

#### 7.1.7 During the incoming inspection the following shall be controlled:

1) overall, coupling and installation dimensions of FA, CPS CR and BAR bundles;

2) summary deviation of the form and layout of FA surfaces;

3) passability of the central tube and the tube under ICDS;

4) FA channels passability;

5) adhesion to CPS CR (BAR bundle) head;

6) correctness of CPS AR (BAR bundle) location in FA;

7) general view of FA, CPS AR, BAR bundle;

8) coding.

9) adhesion to FA cap.

#### 7.1.8 During storage and performance of transport-technological operations with FA, CPS AR and BAR bundles ventilation systems (TL22,32) shall maintain the following environment parameters in RC FFS: air temperature within the range from plus 10 to plus 35 °С, air humidity not higher than 95 %.

7.1.9 All complex of transportation-and technological, control and auxiliary operations at fresh fuel inspection at NPP shall be performed in compliance with the approved Working Programme, taking into consideration the requirements of the manufacturer manual 0401.16.00.000 RE "Complex of the WWER-1000 core components (type V-446). Operation Manual".

7.1.10 Availability of fresh FA including spare ones in the reactor compartment atmosphere during fuel incoming control and accepting is allowed not more than 1 month starting from TPS opening up to insertion to water in the reactor or UU.

**7.2 Safety operation conditions during the reactor refueling**

#### Nuclear safety of works during the reactor refueling is provided by the required sub-criticality of the reactor core as no less than 2 % dk/k (without taking into consideration the inserted CPS AR), which is maintained by injecting a soluble absorber – boric acid at concentration not less than 16 g/dm3 -to primary circuit water and FP. Positional relationship of FP rack cells provides for sub-criticality not less than 5 % dk/k.

FP has cells for unloaded FA, as well as free cells (no less than 163 pcs.) for emergency core unloading.

#### 7.2.1 Prior to refueling operations, the following requirements to the systems and equipment condition shall be fulfilled:

1) The reactor is sub-critical, UU and PTU are removed.

2) During all period of handling the fuel, CPS AR, BAR bundles, monitoring for neutron flux density and the reactor power ascension period is provided using the following facilities of NFME set:

a) 6 channels of NFME source range (DU are located in PV channels).

b) 6 channels of in-core MSR (DU are located inside the reactor vessel).

3) The measures are taken to prevent uncontrolled ingress of “pure” condensate to the reactor, primary circuit, fuel pool, RI inspection cavity (as per OI RP).

4) The Unit auxiliary power supply is performed from the grid via AT or SAT.

5) SS condition shall meet the requirements subjected in “cold” condition mode.

#### The following equipment units shall be operating to remove residual heat from the active core:

#### - one channel of the low pressure subsystem TH10(20,40) (with the operating pump TH10(20,40)D001 or TH18(28,48)D001) – to remove residual heat from the active core according to the scheme of planned cooldown of the primary circuit and one channel of the low pressure subsystem TH10(20,30,40) (with the operating pump TH18(28,38,48)D001 – to cool the fuel pool water.

#### - one channel of the low pressure subsystem TH10(20,40) with the standby pump TH10(20,40)D001 or TH18(28,48)D001 should be ready for use, connected to the primary circuit according to the scheme of the planned cooldown.

- electric circuits of emergency boron injection group pumps TH15,25,35,45D001, extra borating pumps TW10,20,30,40D001 are disassembled;

- electric circuits of valves TJ11,21,31,41S001 at thrust of containment sprinkler system pumps at supply lines to sprinklers are disassembled to avoid false actuation;

- three channels of service water supply VE system for cooling reactor compartment closed circuit consumers TF and safety related consumers closed circuit VJ corresponding to TH system serviceable channel;

- three channels of reactor compartment closed circuit consumers TF and safety related consumers closed circuit VJ corresponding to TH system serviceable channel;

- automatic fire fighting system of four safety systems channels;

- ventilation systems providing normal functioning of SS equipment being in operation or standby;

- I&C providing instrumentation, control and protection of SS serviceable mechanisms are actuated.

6) The following equipment of the fuel handling system shall be completely ready:

- truck tractor for fresh nuclear fuel transportation;

- truck tractor for spent fuel transportation;

- heavy-load trailer for spent fuel transportation;

- transportation packing set for fresh FA;

- transportation packing set for fresh CPS AR and BAR;

- damper for the transportation packing set for fresh FA;

- strop 2СК-5,0;

- semiportal crane;

- lock trolley;

- cantilever crane;

- tilter;

- FFS crane;

- bottle grip;

- cluster grip;

- special grip;

- frame;

- transfer mechanism;

- refueling machine;

- multipurpose seat;

- damper of the fuel pool container section;

- spent fuel transportation container;

- housing grip;

- polar crane;

- vertical cross-arm for the container;

- horizontal cross-arm for the container;

- transportation container damper;

- jig-plate;

- deactivation facility;

- integrity control equipment ТК-13;

- DADS equipment.

7) Steam-generators can be drained by the secondary circuit and prepared for repair and preservation.

8) Fuel pool purification system TG is serviceable.

9) During refueling of one of TH10(20,30,40) channels in tanks TH10 (20,30,40) B001, 002 there should be created a stock of boric acid solution at least 270 m3 – with the filled container compartment and not lower than 390 m3 – with the emptied container compartment, whereby this stock should be in TH10(20,30,40) channel, operating for cooling the fuel pool in case emergency refilling is needed.

FP and its compartments, suction of TH18(28,38,48)D001 pump (working from FP) should be switched over to water intake from TH10(20,30,40)B001,002 tanks. The planned refilling of FP and its compartments should be performed with TH71,72D001 pumps from TH10(20,30,40)B001,002 tanks with subsequent restoration of the above-mentioned volumes in these tanks.

10) DADS - РР is serviceable. Readiness is confirmed by the Act.

11) Communication between MCR, refueling machine control panel, central hall and

radiation monitoring board is provided.

12) FP has at least 163 free cells for placing the spent fuel.

13) In order to fill spent fuel cask pool (V=110 m3), RIs pit (V=500 m3) and reactor barrel (V=700 m3) with boric acid solution with boron concentration at least 16 g/kg it is necessary to use 1310 m3 from the total volume of BAS storage tanks of primary circuit emergency and planned cooldown system.

RIs pit and reactor barrel are filled by means of pumps TH18,28(38,48)D001 through in-house pressure pipelines to reactor. For this purpose the tanks of two SS channels TH10,20(30,40)B001,002 are used with total volume 790 m3.

Filling of cask pool and remaining volume 410 m3 for RIs pit and reactor barrel is performed by means of pump TH71(72)D001 from tanks TH10,20(30,40)B001,002 through filters of AWT-4 facility

For further filling of RIs pit and reactor barrel, 2-nd stage ECCS HA TH16,17,26,27,36,37,46,47B001 are used having total BAS volume 280 m3.

In order to prepare the remaining volume of BAS with concentration 16 g/kg needed for SFP filling, use BAS with concentration 40 g/kg from tanks TW10,20,30,40B003,004 having total volume 35 m3.

Upon refueling completion provided that adequate quality of BAS is assured, restore the rated volumes in tanks TH10,20,30,40B001,002, TH16,17,26,27,36,37,46,47B001, TW10,20,30,40B003,004 from SFP, reactor barrel and RIs pit. BAS quality shall meet the requirements of Appendix F of this technical specification.

7.2.2 Prior to refueling and during it, the following conditions shall be fulfilled**:**

1) The reactor shall be in sub-critical state at least 138 hours.

2) While recharging fuel assemblies, the level of water in the reactor, compartments of the spent fuel and refueling pool should be maintained at least at 3000 mm from the top of the transported irradiated fuel assembly. It corresponds to the level of min. +21,000 m (-0,1 m).

3) Refueling machine including its end switches is in serviceable condition.

4) Boric acid concentration in the reactor coolant system and fuel pool shall be maintained within 16-20 g/dm3.

5) The operations on fuel handling shall not be started until all required equipment is in serviceable condition.

6) Water quality in the fuel pool shall be in compliance with the requirements of Table F.3 in Appendix F.

#### 7.2.3 Additional requirements for performing the operations on the reactor refueling:

1) In refueling mode and during repair activities, the forced and maintenance-and emergency ventilation systems TL22,32 in the reactor building shall be in operation.

2) It is necessary to perform operative monitoring for radiation situation condition in CH.

3) Continuous monitoring for FP water temperature shall be performed, which shall not exceed 50 °С (normal conditions, at the same time the temperature at the reactor top is not more than 70 °С). At FP water temperature increasing up to the values exceeding 55 °С (but not more than 70 °С), reveal and eliminate the reason caused water temperature increasing.

4) During filling the primary circuit and the cavity space, perform thorough air removal from SG headers by the primary circuit and from PRZ.

5) All transportation-and technological operations with FA, CPS AR, BAR bundles are performed in compliance with the requirements of 0401.16.00.000OM using RM, at the same time:

a) horizontal displacement speed - (0,3÷15) m/min;

b) vertical displacement speed - (0,3÷10) m/min;

c) FA vertical displacement speed:

- in the reactor core - 0,3 m/min;

- in CFSR cells, FFS rack storage bottles-cells, DADS boxes, leak-tight storage bottles and transportation container for spent fuel - 0,3÷2 m/min;

d) drag force at FA lifting from the reactor barrel support to the height up to 50 mm is not more than 23000 N;

e) vertical FA pressing force is not more than 9800 N (1000 kgf);

f) drag force at CPS AR displacement is not more than 147 kgf;

g) during FA extraction and setting in the reactor core or FP, weight change as the result of friction shall be not more than 735 N (75 kgf). In case of 735 N (75 kgf) interlock actuation at FA extraction or setting in the reactor core, FP or DADS box, using the refueling machine rope system fix FA height and repeat the operation. At the repeated activation –increase the setpoint up to 1470 N (150 kgf) upon CEP directive, if the interlock is actuated at 1470 N(150 kgf) –increase the setpoint up to 2205 N (225 kgf), upon CEP directive. Upon interlock activation at 2205 N (225 kgf), further actions shall be performed as per the special programme. For all FA having excess of forces over 735 N (75 kgf), perform external inspection using TV camera of the refueling machine.

h) at CPS AR setting, weight loss shall be not more 127 N (13 kgf).

#### 7.2.4 The reactor refueling is forbidden, if:

1) Less than the permissible period (72 hours) has passed from the moment of the reactor shutdown. Water temperature at the reactor core top is more than 70 °С.

2) Residual heat removal from the reactor core due to functioning of at least one TH system channel have not been arranged.

#### 7.2.5 Refueling shall be terminated in the following cases:

1) Coolant temperature increasing in FP and at the reactor core top to more than 70 °С.

2) Boric acid concentration decreasing in the FP, primary circuit coolant to less than 16 g/dm3.

3) At failure of one and more in-core MSR channels.

4) Appearing of stable power excursion period by any measuring channel.

5) At FP water level decreasing below 21,0 m elevation.

6) Drop of FA, CPS AR or any other objects to the reactor core or FP.

7) At failure of RM television system.

8) At actuation of radiation situation sensors in CH.

#### 7.2.6 In “shutdown for refueling” mode the operative personnel shall:

1) monitor by NFME the neutron flux level, the reactor power excursion (NFME source range and in-core MSR), temperature in the reactor and FP.

2) Monitor the level in the reactor and fuel pool.

3) Perform daily sampling and carry out chemical analyses for boric acid concentration content:

a) in the reactor core (circuit TH10(20,30,40));

b) in the fuel pool (circuit TH18(28,38,48)).

Continuous boric acid concentration monitoring in cool-down circuit TH shall be performed automatically.

4) Do not allow uncontrolled ingress of the “pure” condensate to the reactor, primary circuit, fuel pool, control taking of measures preventing ingress of the “pure” condensate to the reactor, primary circuit, fuel pool once a shift (as per OI for RP).

5) Monitor functioning of the system TH10(20,30,40) channels connected to the primary circuit. If functioning of one of the channels is not effective, and temperature at the reactor core top is increasing up to 70 °С, activate the standby channel instead of this.

6) Monitor functioning of channel TH18(28,38,48), at fuel pool temperature increasing up to 55 °С, activate the standby channel.

7) Air removal from the functioning channels TH10(20,30,40), TH18(28,38,48) shall be performed once a shift.

8) Monitor activity of the intermediate circuit of the nuclear component cooling system at the outlet of emergency and cool-down system heat-exchangers.

9) Monitor water chemistry of the fuel pool and perform its correction at TG system filters.

10) Monitor constant serviceability and readiness for operation of at least three channels of each safety system and systems important to NPP safety.

11) Control operation of ventilation systems TL22,32.

12) Monitor radiation situation at the Unit.

**7.3 Sequence of actions, the main rules and methods of performing the refueling operations**

#### 7.3.1 MCC unsealing. The reactor dismantling.

1) MCC unsealing for the reactor refueling shall be performed after triple primary circuit water-exchange and triple primary circuit water level fluctuation in order to remove hydrogen and inert radioactive gases (IRG) via the air-vents.

It is forbidden to unseal MCC without preliminary multiple removal of hydrogen, volatile and gaseous radioactive nuclides, at non-functioning gas treatment system, as well as faulty equipment of the forced and maintenance-and-emergency ventilation system TL22D01, TL32D001,D002.

2) To perform repair activities at the primary circuit equipment during MCC unsealing (without the reactor dismantling), fulfill the same requirements as specified in item 6.2.2.1 of section 6.

3) Prior to MCC unsealing, provide for the following conditions:

a) MCC pressure - atmospheric, coolant temperature at the reactor top - (60÷70) °С;

b) MCC water is drained up to the level below RMJ to (200÷300) mm;

c) boric acid content in the primary circuit is not less than the permitted value - 16 g/dm3;

4) Disconnect connection ribbon cables from CPS drives, ICI sensors, leakage monitoring sensors, as well as from the joints located in the upper part of the concrete cavity, ICDS, TM cold junction compensating units, dismantle the wiring unit and the reactor air vent;

5) Prior to UU dismantling, CPS drive bars shall be uncoupled with CPS AR and mounted to UU in the transportation position.

It is allowed to uncouple the bars with CPS AR from PTU and their mounting to transportation position at PTU after UU dismantling. At the same time, prior to UU dismantling, CPS drive displacement units shall be mounted to the transportation position.

SSU shall personally make sure in CPS CR uncoupling with their drives and make a relevant note in the operative log-book.

6) Dismantle UU;

7) Dismantle PTU from the reactor;

8) At the reactor disassembling for refueling, as well as during the reactor assembling after refueling completion, MCC water level shall not decrease below RMJ elevation more than the permitted value (300 mm).

#### 7.3.2 The reactor refueling. The main rules.

#### The operations on the spent fuel unloading from the reactor to FP, fuel shuffling inside the core and fresh fuel loading shall be performed in a sequence defined by the working program and working schedule of the reactor refueling as well as observing the conditions of section 7.2.

#### The working schedule of the reactor refueling shall be drawn up so that each FA shall be set to the core cell without surrounding FA or at availability of equal surrounding from three sides (as an exception, if fulfillment of this requirement is not possible, it is allowed to set the assembly, if there are two FA from the opposite sides). When setting FA to the peripheral row, the core baffle shall be considered as surrounding at availability of FA at the other sides. If there are no FA at the other sides, consider that FA is set to the cell without surrounding.

1) In refueling process, continuous monitoring for water level and boric acid concentration shall be performed.

2) It is forbidden to drain water from FP without radiation situation monitoring.

3) Upon appearing of the stable power excursion period by any measuring channel detected by at least one of the overloading control devices, all nuclear-hazardous operations shall be terminated until the reasons for the change in the unit readings are revealed and eliminated. If beginning of power excursion, i.e. nuclear-hazardous mode, is detected in the process of a nuclear-hazardous operation performance, immediately terminate performing of the operation and return to the initial condition.

4) It is forbidden to combine horizontal and vertical FA (BAR or AR) displacement by RM operating elements.

5) All complex of transportation-and technological operations with FA, CPS AR and BAR bundles performed by the refueling machine shall be controlled using TV camera mounted at RM.

It is forbidden to perform works in the reactor core, fuel pool, refueling well using the refueling machine with faulty TV camera.

6) In case of damaging FA, CPS AR or BAR bundle during transportation- and technological operations, the issue of their further use shall be solved jointly with the manufacturer representatives.

7) The equipment which is not designed to be transported to/from the fuel pool and the reactor cavity, shall not be transported over them. Transportation of cargoes to CH of the reactor building and placing there the transpiration-and process equipment, dismantled equipment, etc., shall be performed only as per the transportation-and technological chart approved by CEP. The polar crane shall have the electric interlock (interlock «prohibited area»). The interlock tripping is allowed only in case of the hydraulic locks removal and mounting, displacement of FP rack sections (during FP liner repair) and sealed boxes.

#### 7.3.3 Sequence of operations during the reactor refueling.

#### The operations on the spent fuel unloading from the reactor to FP, fuel shuffling inside the core and fresh fuel loading shall be performed only using the refueling machine, in the sequence defined by the reactor refueling map, working programme and working time-schedule at constant control of the supervisory physicist:

1) Move RM to the defined coordinate of FA to be extracted from the reactor core, make sure in preciseness of RM reaching the defined coordinate.

2) Perform adherence with FA cap by RM bar. Adherence (disengaging) of the screw grip with FA and FA position after lifting to the transportation position shall be monitored using TV camera.

3) Observing the precautions, extract FA for the reactor core. Displacement speed by all core height is 0,6 m/min.

4) RM shall transport FA in the transportation position to FP, move to the defined coordinate of the FP rack cell, to which it is required to set the extracted FA.

5) make sure in preciseness of reaching the defined coordinate and move-down FA to FP rack cell. Displacement speed by all rack height (CFSR) is 0,6÷2 m/min.

6) Disengage RM bar and FA.

7) FA reshuffling in the core shall be performed as per the reactor refueling map as per the requirement of sub-items 7.3.3.1)-7.3.3.6).

8) CPS AR shuffling in the reactor, and BAR bundles and CPS AR unloading from the reactor to FP shall be performed as per the operating instruction for RM and in compliance with the reactor refueling map. At the same time the bundle lifting and moving down within the core or FP rack shall be performed at speed 0,6÷2 m/min. When setting CPS AR to FA, weight loss shall not be more than 130 Н (13 kgf).

9) Perform FA reloading from FFS rack to the reactor.

10) After full reactor core loading, perform check of FA caps arrangement by height and FA caps inspection in the outline. Difference in FA caps height at equal lifetime shall not exceed 5 mm.

11) Perform inspection of coding available at FA caps and complete set of CPS AR FA and BAR bundles in order to check correspondence of FA, CPS AR and BAR bundles arrangement in the core to the reactor refueling map.

12) Perform inspection of FA caps in the reactor core in order to check unavailability of extraneous items.

13) Upon refueling completion for PTU installation to the reactor, drain reactor cavity volume to (200÷300) mm below RMJ.

7.3.4 Sequence of operations at reactor fuel FCIM.

1) Volume of FE FCIM shall be defined depending on fuel cladding condition as per the "Instruction on FFDS".

If it is required to perform FCIM for FA FE left in the reactor, as well as those which are to be unloaded to FP but planned for further operation, FCIM shall be performed by measuring of reference radionuclide activity, including iodine-131, xenon-133, cesium-134 and cesium-137.

FA fuel element tightness control by measurements of iodine-131, xenon-133 activity shall be performed within 40 days from the moment of RP shutdown.

Monitoring the tightness of casings of fuel assembly elements by measuring the activity of cesium-134 and cesium-137 can be performed throughout a year after the RP shutdown.

2) During FA FE fuel failure detection as per sub-items 7.3.3.1)÷7.3.3.6), transport them one by one from the reactor to FP using RM, and set them to DADS bottles.

Sealing DADS bottles with plugs, as well as their unsealing after completing FA FE fuel failure detection shall be performed by RM operating bar as per the operating instruction for DADS sampling part and the operating instruction for RM.

1. Depending on the results of the sample analysis, checked FA shall be extracted from DADS bottle as per the requirements of sub-items 7.3.3.1)÷7.3.3.6) and set either to the

defined FP rack cell or returned to the reactor again, or to the empty sealed bottle.

Leaking FA, during FCIM of which the specific iodine 131 activity exceeded the individual rejection criterion specified in the contract for fuel delivery, shall be placed to the sealed box.

4) RM shall move to the defined coordinate of the sealed box seat, make sure in RM preciseness, adhere the box plug and RM bar and extract the plug from the seat as per the operating instruction for RM. Torsion torque transmitted by RM operating bar to the plug during its extraction form the seat shall not exceed 100 kgf×m.

5) Raise RM operating bar a little using TV camera, and make sure in availability of the sealed box plug on the bar.

6) RM shall move to the coordinate of the sealed box with the set FA, make sure in preciseness of approach, mount and close the plug at the box as per the operating instruction for RM. Torsion torque transmitted by RM operating bar to the sealed box during closing the plug shall not exceed 100 kgf×m.

7.3.5 All complex of transportation-and technological operations with CPS AR, CPS and BAR bundles related to the reactor core loading and unloading shall be performed in compliance with the approved Working Programme, taking into account manufacturer manual 0401.16.00.000 RE "Complex of WWER-1000 core components (type V-446). Operation Manual".

7.3.6 At performing of transportation-and technological operations with FA, refueling machine control system shall provide trip of the operating bar displacement drive in case of FA weight change to more than ± 735 Н (± 75 kgf) as the result of friction to adjacent FA.

**7.4 Dispatching of spent FA**

**7.4.1 General**

#### 7.4.1.1 During transportation-and technological operations with spent FA (SFA),only serviceable regular facilities and mechanisms shall be used, which have passed periodical witnessing, testing and control inspection prior to performing the operations.

#### 7.4.1.2 During transportation-and technological operations with SFA, the following possibilities shall be prevented:

1) occurring of extraneous objects to SFA, housings, containers ТК-13;

2) SFA overheating due to residual heat releasing;

3) loss of FE integrity due to impermissible mechanical effects to FA.

#### 7.4.1.3 At FP water level decreasing and radiation monitoring alarm activation, the personnel shall immediately leave CH.

#### 7.4.1.4 The operations on SFA loading to TK-13 and operations with loaded TK-13 shall be performed in the sequence defined by the working program and fulfilling the conditions of section 7.4.3.

7.4.1.5 SFA shall be removed from the reactor compartment prior SFA unloading from the reactor.

**7.4.2 Requirements to operating parameters of TK-13 container during SFA shipment and dispatching**

#### 7.4.2.1 Maximum operating pressure in the container, MPa (kg/cm2) – not more than 0,69 (7).

#### 7.4.2.2 Pressure in the neutron protection tank not more than, MPa (kg/cm2) - 0,7 (7).

#### 7.4.2.3 Maximum temperature of the outer container surface on the auto-trailer (taking into account solar radiation and outdoor temperature 38 °С) is not more than:

1) 96 °С – al loading to SFA container with summary power-flux not more than 17 kW;

2) 102 °С - al loading to SFA container with summary power-flux more than 17 kW.

#### 7.4.2.4 Maximum temperature of the inner container cavity with SFA - not more than 150 °С.

**7.4.3 Safety operation conditions during activities on dispatching SFA loaded to container ТК-13, as per readiness of the systems and equipment**

#### 7.4.3.1 The inspection have been performed and serviceability of the following systems and equipment have been confirmed:

1. polar crane;

2) cross-arms for ТК-13 (horizontal and vertical);

3) tools for TK-13 sealing and unsealing;

4) deactivation system;

5) lighting of the gantry, material lock and reactor hall in the confinement;

6) containment ventilation systems;

7) material lock;

8) lock trolley;

9) power supply source 380/220 V under the gantry;

10) platforms for TK-13 sealing, unsealing;

11) supports with the deactivation tray;

12) dosimeters;

1. helium leak detector;
2. nitrogen supply systems for drying-out the internal cave of the container ТК-13;
3. dams of container ТК-13 and container section;
4. semiportal crane;
5. housing grip;
6. refueling machine;
7. truck tractor for the spent fuel transportation;
8. heavy-load trailer for the spent fuel transportation;
9. jig-plate
10. polar crane;
11. universal traverse.

#### 7.4.3.2 Prior to each operation, visually inspect adherence of the cross-arm and the container pivots, as well as the container mounting to the transportation trolley.

#### 7.4.3.3 Safety operation conditions specified in item 7.2 are fulfilled.

**7.4.4 The main sequence of activities at SFA loading to ТК-13**

1. Prepare and drive the trailer to the reactor building.
2. Prior to mounting ТК-13 to the container section, perform ТК-13 incoming inspection (antifreeze level measuring, internal cave inspection, etc.), in the deactivation facility.

3) Prepare and mount container TK-13 to the container section for loading SFA. During mounting the container to the container section, perform correction by the reactor axes. The temperature of the outer container surface shall be not lower than (10÷20) °С.

4) Start SFA reloading from FP racks to container ТК-13.

5) Mount ТК-13 cover;

6) Mount hydraulic lock between FP and the container section and seal it.

7) Transport the container with SFA from the container section to the support with deactivation tray after completing its inner cave draining.

8) Seal container ТК-13 cover and inspect for tightness of the container joint connections, penetrations and valves.

9) Perform deactivation of the outer container ТК-13 surface.

10) Monitor equivalent dose rate of the outer container ТК-13 surface ionizing radiation and inner ТК-13 cave temperature.

1. Transport the container with SFA to the lock trolley.
2. Transfer ТК-13 to the horizontal position, transport the lock trolley to the transportation gantry via the material lock, mount TK-13 to the shock absorber, transport ТК-13 from the transportation gantry and mount to the truck.

# 8 THE UNIT CONTROL IN CONDITIONS OF MALFUNCTIONS IN NORMAL OPERATION AND ACCIDENTS

8.1 In case of disturbances in normal operation and during emergencies the operative personnel headed by SSP shall take all possible measures to restore its normal operation.

If it is impossible to recover normal operation of the Unit, the operative personnel shall control and provide for activation of the emergency (preventive) protection, SS, protective units and functioning of interlocks, boric acid injection to the primary circuit, and take measures for stabilizing the parameters at the safe level.

8.2 At disturbance of normal Unit operation, the operative personnel under head of SSP shall:

* notify by radio-searching and operative communication all operative personnel of the Unit as well as CEP, DCEO and the telephone operator for notification of all the personnel as per the list approved by NPP Director;
* quickly and correctly find out the reason for disturbance in normal operation by readings of the devices and alarm, as well as by the messages from the operative personnel from their workplaces;
* make sure in correctness of the Unit equipment protections and interlocks activation; if some of the protections or interlock failed to activate, make the switchovers envisaged by these protections (interlocks) remotely or using the manual drives;
* take measures on stabilizing the Unit parameters at the safe level;
* arrange continuous monitoring for radiation situation in the constantly attended premises of the Unit and monitoring for the radioactive isotope release to the environment;
* arrange evacuation of the personnel from the premises of the Unit, where the conditions hazardous for their life and health occurred, and with help of the subordinate personnel arrange taking of measures preventing the personnel access to these premises.

8.3 After emergency it is required to accumulate compete information on the emergency development, check FE integrity by the primary circuit coolant activity, by the results of the accumulated information analysis, it is necessary to establish observation of the safe operation limits stipulated in section 3.

8.4 Regardless of the administrative-and technical personnel presence at the Unit, the operative personnel of the Unit is personally responsible for the emergency or disturbances in normal operation mitigation individually taking the decisions and measures on recovery of the normal Unit operation.

NPP Director, CEP DCEO are entitled to remove any person from the operative personnel of the Unit and entitle his responsibilities to another person or take upon himself liquidation of the emergency or normal operation disturbance consequences, preliminary making the relevant note in the operative log-book of the removed person.

8.5 It is forbidden to interfere into functioning of automatics, protections or interlocks, except for cases of their failure.

8.6 In the process of emergency (disturbance of normal operation) liquidation at the Unit, the operative personnel headed by SSP shall provide for:

1. non-admission of the uncontrolled reactor power increasing;
2. reliable cooling of the reactor core;
3. non-admission of running RCPS, FWP stoppage;
4. reliable operation of deaeration and feeding facilities of the Unit;
5. reliable operation of RP cool-down system;
6. pressure in the Unit vessels and pipelines to be not more than the permitted one;
7. non-admission of water spreading to the steam-lines and flow-through part of the turbine;
8. oil supply for turbine rotating rotors bearings lubrication;
9. non-exceeding of the limit values for the axial offsets and relative expansions of the turbine rotors;
10. preventing of blocking in the flow-part of the turbine;
11. preventing of non-admitted turbine rotation frequency increasing;
12. reliable Unit HL power supply;
13. taking the measures required to prevent water, steam, nitrogen leakage from the Unit equipment and pipelines and localizing of the occurred leakage as well;
14. preventing of ignition and fire fighting;
15. fulfillment of conditions on brittle and thermocyclic strength of RP equipment units;
16. operation of SS and supporting systems within the time sufficient for the emergency liquidation;
17. in case of any emergency the operative personnel shall provide for residual heat removal form the reactor core and eliminate possibility of coolant loss.

8.7 The specific actions of the operative personnel on the certain accident (disturbances in normal operation) liquidation are defined by the following documents:

1. Instruction on emergency liquidation at the BNPP-1 reactor plant 52.BU.1 0.00.AB.WI.ATEX.003;
2. Manual on beyond-design basis accidents management 52.BU.1 0.00.AB.WI.ATEX.008;
3. Instruction on malfunctions liquidation in the turbine compartment   
   52.BU.1 ZF.00.AB.WI.ATEX.004;
4. Instruction on liquidation of malfunctions in the electrical part of the Unit 52.BU.1 0.00.AB.WI.ATEX.005;
5. Instruction on liquidation of malfunctions in APCS operation  
   52.BU.1 0.00.AB.WI.ATEX.006;
6. OI for the Unit systems and equipment;
7. BNPP-1 fire fighting plan 52.BU.1 0.00.AB.WI.ATEX.021.

In case of radiation accident, actions of the operative personnel are additionally defined by «Emergency plan on the personnel protection at BNPP-1» 52.BU.1 0.00.AB.WI.ATEX.015.

8.8 Sequence of RP processes control changeover from MCR to ECR and sequence of the personnel actions in such cases shall be defined by an individual instruction.

8.9 The Unit control from ECR is allowed only for its cool-down and shutdown in case if personnel attendance in MCR is not possible or in conditions endangering lives of the operative personnel at MCR.

8.10 At normal operation of the Unit, ECR compartment shall be closed and sealed by APCS seal.

8.11 Shift operating personnel shall immediate shut down the reactor by pressing appropriate buttons of emergency protection system in MCR or ECR in the following situations:

8.11.1 in case any of EP signals was generated and the protection system was not actuated (in the hot condition before the elimination of the defect);

8.11.2 in case there occur some malfunctions or a failure in two or more than two different EP channels in the modes «Power operation» and «Reactor at MCL»;

8.11.3 in case of malfunction in two different EP channels of one set in the mode «Reactor at MCL»;

8.11.4 in case of malfunction in two different EP channels of different in the mode «Reactor at MCL»;

8.11.5 in case of failure of two sets of EP actuating part in the modes «Power operation» and «Reactor at MCL»;

8.11.6 in case of failure of two and more channels of the working range of one NFME set in the modes «Power operation»

8.11.7 in case of failure of two and more channels of one NFME set in the mode «Reactor at MCL»;

8.11.8 in case the monitoring system of the reactor neutron power is not actuated in two out of three channels of any NFME sets (in the hot condition before the elimination of the defect);

8.11.9 in case the monitoring system of the reactor power increase is not actuated in two out of three channels of any NFME sets (in the hot condition before the elimination of the defect);

8.11.10 in case there is no monitoring of the following parameters:

1. pressure in the primary and the secondary circuits;
2. temperature of water at the output from the reactor active core;
3. water level in SG of any loop with the RCPS in operation;
4. pressure drop in any of RCPS during the operation of the Unit and two RCPS units;
5. pressure drop in the reactor active core;

(in the hot condition before the elimination of the defect);

8.11.11 in case there occurred an uncontrolled continuous movement of CPS CR reactor group upwards caused by failures in the control circuit (accompanied with transferring of RP in the hot condition);

8.11.12 in case there occurred an uncontrolled continuous movement upwards of any of CPS CR or a group of CPS CR (accompanied with transferring of RP in the hot condition);

8.11.13in case two or more CPS CR dropped to LLS (accompanied with transferring of RP to the hot condition);

8.11.14 in case there occurred a failure of design order of CPS CR group movement (accompanied with transferring of RP in the hot condition):

1. moving of several CPS CR upwards with the wrong group;
2. absence of automatic movement transferring between CPS CR groups;
3. simultaneous movement of two groups when they are higher than 50% from the active core bottom.

8.11.15 in case there is a leakage of the primary circuit coolant to the secondary one exceeding the rate of 5 kg/h (accompanied with transferring of RP in the hot condition);

8.11.16 in case there occurred a failure of one RCPS out of two operating units, which requires shutting it down according to the RCPS operating instruction (accompanied with transferring of RP in the hot condition);

8.11.17 in case the water feeding of the component cooling system was blocked to all RCPS units (accompanied with transferring of RP in the hot condition);

8.11.18 in case the three make-up pumping units failed (cold condition before the elimination of causes and consequences);

8.11.19 in case all feedwater pumps at RP power level exceeding 25 % (accompanied with transferring of RP in the hot condition);

8.11.20 in case of any signs of MCR personnel poisoning with gases having asphyxiating, poisoning or narcotic effect (cold condition before the elimination of causes and consequences);

8.11.21 in case of fire in one or more rooms (Table 8.11.16.1):

Table 8.11.16.1

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| No. | Room No. | Room description | Effect on safety (fire hazard) | Final condition of RP after EP actuation |
|  | E0905 | MCR operating circuit | Loss control form MCR.  Transferring of personnel to ECR. | cold |
|  | E0910а | Room for MCR non-operating circuit | Loss control form MCR. | cold |
|  | E0807 | NO cable floor SS channel 4 | Loss control form MCR.  Transferring of personnel to ECR. | cold |
|  | E0808 | NO cable floor  SS channel 1 |
|  | E0809 | NO cable floor  SS channel 3 |
|  | E0810 | NO cable floor  SS channel 2 |
|  | X0425 | ECR room | Loss of control from ECR | cold |
|  | Х0431 | Cable basement  SS channels 1÷4 | Loss of control from ECR | cold |
|  | E0904 | RCD and SHC-W room  SS channels 1÷4 | Loss of remote control of the safety system 1÷4 channels | cold |
|  | E0703 | CPS room No. 1 | Loss of power supply cabinets and CPS control | cold |
|  | E0704 | CPS room No. 2 | Loss of power supply cabinets and CPS control | cold |
|  | E0705 | CPS transformer room | Loss of CPS transformers | cold |
| No. | Room No. | Room description | Effect on safety (fire hazard) | Final condition of RP after EP actuation |
|  | E01008 | Ventilation chamber of CPS and FIS rooms | Loss of power supply cabinets and CPS control | cold |
|  | B0219 | Room for make-up pump drives and oil supply system | Loss of the three operating make-up pumps | cold |
|  | B0702/1 | Cable corridor | Loss of power supply and control cables of NO system equipment of the primary circuit. EP actuation after trip of two RCPs | cold |

Table 8.11.16.1, continued

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| No. | Room No. | Room description | Effect on safety (fire hazard) | Final condition of RP after EP actuation |
|  | B0702/2 | Cable corridor |  |  |
|  | B0703/2 | Cable corridor |  |  |

8.12 In case of fire at the Unit, the personnel actions are defined by «BNPP-1 fire fighting plan»» 52.BU.1 0.00.AB.WI.ATEX.021.

8.13 In case of the accident related to the earthquake as an initial event, the operative personnel headed by SSP shall:

* control and duplicate EP activation;
* control for the state of systems, equipment and pipelines. Incase of any damages, the measures on localizing their consequences shall be taken;
* act depending on the certain situation at NPP and changeover the Unit to «cold» condition.

8.14 At WC upsets, personnel actions shall be defined by the requirements stated in Appendix F of this specification.

8.15 In case of actuation of EP operating personnel shall double EP actuation with key.

8.16 Unit must be shut down and switched into “hot condition” mode in the event of tank farm filling of drain water treatmnt system TR71-73B001.

# 9 Organizational issues of the unit operation

**9.1 General issues**

#### 9.1.1 Delimitation of functions, responsibilities, service areas of systems and equipment, premises, buildings and structures shall be defined by the relevant BNPP-1 provisions and standards.

#### 9.1.2 General operative management by NPP, Unit is performed by the shift supervisor of the plant and shift supervisor of the Unit respectively. Operative maintenance of the Unit equipment is performed by the personnel from the relevant subdivisions.

#### 9.1.3 Any tests of the system important to safety which are not envisaged by the technical specification and the operating instructions shall be performed as per the programs and test procedures containing safety justification and measures on their safety assurance. Programs and test procedures shall be agreed upon by the NPP designers and approved by NPP operating organization. The tests shall be permitted by the regulatory authority as per conditions of changeover from one stage of works to another one stipulated in the license, and shall be performed by permit of NPP operating organization.

#### 9.1.4 Any scheduled change of the Unit power as well as its startup and shutdown shall be performed only by permit of the relevant organization in the Grid.

#### 9.1.5 Based on the design documentation and operation experience, the list of nuclear-hazardous works shall be developed at NPP.

#### 9.1.6 The lists (list) of works to be performed as per programs and switchover forms shall be developed at the Unit and approved by CEP. The programs and switchover forms shall contain sequence of operations and safety measures.

#### The lists of premises and lockable valves shall be developed, specifying the operative documentation where their state shall be recorded.

#### 9.1.7 Withdrawal from operation for scheduled maintenance, reserve or for testing of the equipment influencing power output to the Grid, as well as its putting into operation shall be drawn up through submittal a request to the Grid within the established period. Regardless of availability of the approved request, scheduled withdrawal from operation and putting into operation may be performed only by permit of the relevant organizations of the Grid directly prior to the equipment withdrawal or startup.

#### 9.1.8 In compliance with the requirements of the design and regulatory documents, periodical serviceability check of the safety systems, system (elements) important to safety, control systems, base metal and welded joints of NPP systems and elements important to safety shall be performed. Frequency and scope of the periodical checks shall be established by the schedules, which shall correspond to the requirements of the regulatory documents. By demand of the regulatory authority, extraordinary serviceability checks of the safety systems may be performed.

#### 9.1.9 Control and monitoring systems shall pass periodical checks as per the existing procedures and instructions as per the schedules approved by NPP Chief Engineer. Start-up of the process protections after installation or reconstruction shall be performed by written request of NPP Chief Engineer. Process protections put into regular operation shall be in switched-on condition within all operation period of the equipment which they are protecting. Protection devices having units for changing the setpoints shall be sealed or stamped (except for recording devices). Only personnel of the subdivisions servicing these devices are allowed to remove seals (stamps), making the relevant record in the operative log-book.

#### 9.1.10 Functioning equipment serviceability control shall be performed by the operative personnel:

1) by process parameters values;

2) by serviceability (failure) features, revealed in the course of external inspection during walk-down or using the special systems: absence of leakage by welded, flanged joints, gaskets; integrity of the equipment external structures, heating of its surfaces; lubrication fluid (oil) level at availability of the external indicators; serviceability of the locking and control unit position indicators, thermal structure expansion indicators, lines with the equipment and devices, serviceability of the grounding units, local lighting, fire-fighting units, serviceability of I&C units mounted on the equipment and integrity of their seals; cleanness of the equipment and the premises with the restricted access, serviceability of their door locks, etc.;

3) by values of the technical condition parameters (characteristics);

4) serviceability check (“reciprocation” and etc.) of the protective units built-in to the process systems at the operating modes, as per the equipment designer’s directives in the operational documentation;

5) periodical serviceability check of the safety system in compliance with the directives in the operating instructions and technical specification.

#### 9.1.11 Managers of NPP and its structural subdivisions shall perform walks-down and inspections of the workplaces at NPP, including the night hours. Walks-down shall be performed as per the schedule.

#### 9.1.12 The recording shall be kept of the equipment operation cycles, neutron fluence, operation at power time, and other parameters defining the operation lifetime as per the technical conditions.

#### 9.1.13 The reactor core refueling maps shall be stored at the subdivision in charge within the whole NPP service life.

#### 9.1.14 The premises, where operational SS equipment is located, shall be closed for access of the unauthorised persons.

**9.2 Organizational operational issues during the Unit preparation for startup and startup**

#### 9.2.1 The Unit startup after repair, as well as after shutdown caused by malfunctions in the Unit operation, shall be performed by permit of the operation organization at availability of positive results of the special inspection performed by the regulatory authority. The justification for permit and arrangement of the special inspection for the Unit startup is the information on fulfillment of the scheduled works and readiness of the Unit for startup. The justification for permit and arrangement of the special inspection for the Unit startup after shutdown caused by malfunctions in operation, is the information on elimination of reasons for malfunctions.

#### 9.2.2 After completing the repair of the equipment and systems important to safety, the characteristics of these systems shall be checked for correspondence to the design characteristics. The check shall be performed as per the programs drawn up by NPP administrative managers based on the documents developed (agreed) by NPP and RP designers.

#### To check (test) NPP systems and the main facilities of the Unit in operation after repair (maintenance), the working committees shall be arranged as per the order at NPP, which shall be headed by the managers of the relevant structural subdivisions. As a rule, these committees include leading specialists responsible for serviceable condition of the systems, specialists-supervisors, other specialists, if required.

#### Check of the auxiliary equipment of the Unit shall be performed by the committees headed by engineers assigned by managers of relevant subdivisions.

#### The organizational-and administrative documentation shall be drawn up on introducing changes to the operational documentation, on familiarization of the personnel with all changes, as well as list of modifications in the diagrams and structures of the equipment.

#### 9.2.3 At the stages of the Unit preparation for startup, the readiness of the equipment, documentation and the personnel shall be confirmed by managers of the subdivisions-owners of the equipment in the log-book of directives at SSU workplace. The permit for conducting the stages shall be given by CEP.

#### 9.2.4 The Unit startup after repair, as well as after shutdown caused by malfunction in operation shall be performed by the written directive of the Chief Engineer. The directive shall be made in the log-book of technical directives with indication of the permitted level of power and assignment of the startup responsible manager. Deputy chief engineer or SSP may be assigned as the startup responsible manager.

#### 9.2.5 Bringing the reactor to the critical state and further power increasing until the automatic power controller activation shall be performed under supervision of the startup responsible manager.

#### 9.2.6 Preparation for startup and the startup of the Unit after any shutdown except for the short-term one shall be performed as per the schedule developed and approved by NPP management. The schedule shall unambiguously define the list of checks and tests to be performed during this specific test.

#### Bringing the reactor to MCL of power from the sub-critical state after the reactor refueling, as well as after any, except short-term, reactor shutdown shall be performed in presence of a representative from the subdivision responsible for nuclear-physical maintenance of the RP (on duty supervisory physicist).

#### At any approaching of the reactor to power from sub-critical state, SSRC shall be at MCR of the Unit and control SERC actions until APC is activated.

#### 9.2.7 Upon hydraulic tests completion, prior to RP heat-up up to the nominal parameters, the confinement shall be sealed, at the same time the primary circuit process premises shall be checked as per the approved list for absence of people, burnable and explosive objects. Upon the check completion, this premises shall be closed and sealed.

#### Interlock for opening–closing of the main and emergency locks shall be activated.

#### The check results shall be recorded in the operative log-book of SSU.

#### 9.2.8. All activities on preparation for startup and startup of the Unit shall be performed by the operative personnel headed by SSU upon permit and under supervision of SSP.

**9.3 Organizational operational issues during the Unit operation at power**

#### 9.3.1 Any scheduled Unit power variation, as well as its scheduled shutdown shall be preformed by written permit of SSP made in the operative log-book of SSU as per the requirements in item 9.1.4. The operations on power variation shall be performed under the direction of SSU. If required, as per SSU request, the estimated prediction of the upcoming power variation and further reactor operation shall be performed.

#### 9.3.2 Tests and checks of the systems and elements important to safety shall be performed by the instructions, programs and schedules approved by CEP.

#### 9.3.3 Prior to pressure increasing over 1,8 MPa (18,4 kgf/cm2), disconnect the low-pressure pipelines of RP auxiliary systems from the high pressure valves using the interfacing valves of this equipment.

#### Disassemble the electric circuit of the gate valves power supply, provide the indication of the limit switches for remote control of boundary valves position. Lock fly-wheels of the drives. Close and seal the gate valves power supply cabinets.

#### The valves power supply circuit shall be assembled only by directive of SSP making the relevant record in the operative log-books of SSU, SSRC, SS APCS.

#### The following shall be controlled every shift with a relevant record in the operative log-book:

1) SSU - condition of the interfacing valves by position indication at MCR panels and I&C fragments;

2) SS APCS – closed and sealed state of the interfacing valves power cabinets.

#### 9.3.4 Setpoints of protections, interlocks and alarm shall be set in compliance with the list.

#### 9.3.5 At ICIS units functioning, the personnel of APCSD and NFSD shall control the state and trustworthiness (once every shift) of ICDS signals with their serviceability analysis.

#### 9.3.6 It is allowed to open the interfacing valves on the air removal pipeline from RCPS off-line circuit only by SSU directive.

#### 9.3.7 It is forbidden to unseal the sealed premises of the confinement during the reactor plant operation.

#### Confinement unsealing is allowed, if the reactor plant is in «cold» condition, «shutdown for repair», «refueling» condition.

#### If required, the personnel admission to the confinement (containment) at different conditions of the reactor plant shall be performed through locking as per the special instruction.

#### 9.3.8 Withdrawal of the normal operation systems, devices or equipment for repair causing to operation without redundancy for the time of repair shall be allowed only by CEP written permit.

**9.4 Organizational issues at the Unit shutdown**

#### 9.4.1 The permit for scheduled shutdown shall be given by SSP after obtaining the relevant permission form the dispatcher control organizations. If required, in order to define the main parameters of the process equipment, prior to the Unit withdrawal for the scheduled maintenance, managers of subdivisions-equipment owners shall arrange operational tests as per the program agreed and approved in the established procedure.

#### 9.4.2 The operations related to the scheduled unloading of the Unit and its shutdown shall be performed by the operative personnel upon SSU directive.

#### 9.4.3 The repair, maintenance, checks and tests of the systems and elements shall be performed with drawing up the relevant permit as per the procedure established at NPP.

#### 9.4.4 Prior to the scheduled maintenance of the Unit , the schedule of works shall be drawn up as per the established procedure and in due time. The control for work performance shall be provided.

#### 9.4.5 All activities related to fresh and spent fuel handling shall be performed in compliance with the special programs approved by NPP Chief Engineer and agreed with the deputy chief engineer on nuclear safety. If required, the programs shall specify the additional safety measures unforeseen by this specification.

#### 9.4.6 Prior to the upper unit removal, as well as prior to PTU extraction, SSU shall personally make sure in uncoupling of each CPC CR bars. SSU shall make a note in the operative log-book on uncoupling of all CPS drives with their bars.

#### 9.4.7 In the reactor refueling period, SERC (SSU) shall monitor the readings of MSR devices, NFME indicators at MCR, SERC shall immediately notify RM control panel on stable reactor period decreasing, neutron power increasing, emergency or preventive signalization, as well MCR, ECR MSR and NFME malfunctions.

#### 9.4.8 The personnel shall be admitted for works at the unsealed primary circuit and the reactor in compliance with the requirements of the special instruction. At the same time:

1) the personnel directly performing the activities shall wear the suits without buttons;

2) handheld units shall be reliably fixed against drop;

3) the possibility of extraneous objects penetration to the reactor, FP shall be excluded;

4) all operations on the nuclear fuel transportation within NPP shall be performed in compliance with the preliminary developed programs and working schedules with mandatory safety control.

**9.5 Organizational issues related to NPP radiation safety assurance**

#### 9.5.1 NPP administration shall record the personnel exposure doses, development and implementation of measures on decreasing exposure of NPP operating personnel and the maintenance personnel invited from other organizations up to the reasonable achievable level.

#### 9.5.2 NPP administration shall provide for recording the quantity, location and displacement of fission and radioactive materials, fresh and spent fuel, dismantled radioactive equipment, contaminated tools, clothes, industrial wastes and other ionizing radiation sources.

#### 9.5.3 The following shall be provided at NPP:

1) radiation-and process monitoring;

2) radiation-and dosimetric monitoring of premises;

3) individual dosimetric monitoring;

4) environmental radiation monitoring.

#### 9.5.4 The control for closing of the controlled access area, containment premises shall be provided at NPP.

#### 9.5.5 The operative information on important radiation parameters, for which the safe operation limits are established, shall be available at MCR and ECR, as well as for the operative personnel responsible for NPP maintaining in radiation-safe condition. The information shall be provided to SSU and SSP.

#### 9.5.6 Besides the stationary equipment, the portable devices shall be available at NPP to measure the radiation parameters for which the safe operation limits are established. Emergency set of devices shall be envisaged for these activities.

#### 9.5.7 Continuous monitoring for quantity of the radioactive materials in the liquid drains, or in case of liquid wastes accumulation in the storage tank, periodical control shall be arranged prior their discharge to the environment.

#### 9.5.8 Continuous and/or periodic control for quantity of the radioactive materials in the gas-and aerosol releases to the environment.

#### 9.5.9 At planning radiation-hazardous activities, external radiation exposure doses shall be calculated based on the results of radiation-dosimetric monitoring of premises.

#### 9.5.10 All NPP personnel and involved personnel working in the controlled access area shall be subjected to the individual dosimetric control as well as on-business personnel attending this area.

#### 9.5.1. NPP personnel shall strictly observe the regime of areas established by the regulatory documents. The procedure of crossing the established area boundaries by people and radioactive materials is defined in the relevant instructions approved by NPP administration.

#### 9.5.12 NPP administration shall systematically analyze the results of the personnel medicine and dosimetric control as well as radiation monitoring at NPP and surrounding area.

#### 9.5.13 The data on the individual dosimetric control and the personnel exposure doses as well as the persons attended the controlled area exposure doses shall be stored within all NPP service life. The data on the personnel exposure and occupational diseases shall be submitted to the relevant supervisory authorities.

#### 9.5.14 A special instruction shall be available at NPP, regulating recording and control for fissionable nuclear materials and ionizing radiation sources, measures and means providing for effective records keeping.

#### 9.5.15 At least once a year, NPP inventory committee shall perform checks of the actually available quantity of fissionable and radioactive material, define their quantity, composition and perform their measurements as well.

#### 9.5.16 At recording the fuel using I&C, it is allowed to keep all information on the magnetic media with duplicating in the log-books.

#### 9.5.17 Material-and balance recording documents shall be stored at least three years after spent fuel dispatching from NPP.

**9.6 Organizational issues related to safety operation assurance at deviations from normal operation**

#### 9.6.1 The specific actions of the operative personnel on conducing the process operations in case of disturbances in normal operation and accidents considered in the design shall be defined by the following documents:

1) operating instructions (OI);

2) Instruction on emergency liquidation at the BNPP-1 reactor plant 52.BU.1 0.00.AB.WI.ATEX.003;

3) Instruction on malfunctions liquidation in the turbine compartment  
52.BU.1 ZF.00.AB.WI.ATEX.004;

1. Instruction on liquidation of malfunctions in the electrical part of the Unit  
   52.BU.1 0.00.AB.WI.ATEX.005;
2. Instruction on liquidation of malfunctions in APCS operation  
   52.BU.1 0.00.AB.WI.ATEX.006.

#### At non-design development of an accident, the operative personnel shall act in compliance with the “Manual on beyond-design basis accidents management”.

#### 9.6.2 In case of an accident occurrence, the actions of the personnel are additionally defined by “Emergency plan on the personnel protection at BNPP-1”. NPP administration shall notify the relevant authorities about an incident at NPP as per the established procedure.

#### 9.6.3 In absence of the director or its deputy, the person directly responsible for initial evaluation of an accident, and taking a decision on bringing in force “Emergency plans on the personnel protection at BNPP-1 in case of the radiation accident” is SSP.

#### 9.6.4 RP operator is entitled and shall singly shutdown the reactor in cases, envisaged by the technical specification, and if further operation endangers NPP safety.

#### 9.6.5 If in some premises of the Unit the conditions hazardous for lives and health of people occurred, SSU shall arrange evacuation of personnel from these premises and with help of his subordinates provide for taking the measures preventing personnel access to these premises.

#### 9.6.6 SSP shall notify on all malfunctions in the Unit operation. The notifications shall be made as per the lists of organizations and officials depending on the malfunction type.

#### 9.6.7 At operation with deviations (with violation of the operational limits or conditions but without violating safe operation limits and conditions), the operative personnel shall restore the normal operation, and in case of impossibility to resort it, the reactor shall be shutdown.

#### 9.6.8 During operation, accumulation, processing, analysis, storage of the information on failure of system elements important to safety and the personnel mistakes shall be provided at NPP.

#### 9.6.9 Withdrawal of individual safety system channels from readiness condition, not related to elimination of the channel elements failure, for the time permitted by this technical specification shall not be considered as malfunction in the Unit operation.

#### 9.6.10 Occurred violations of the safe operation limits and conditions including accidents shall be thoroughly reviewed by the committees in compliance with the existing provisions.

#### 9.6.11 Prior to establishing a committee on investigation of malfunction in NPP operation, NPP administration shall take measures on keeping the situation at the place of malfunction such as it was during malfunctioning, terminate all activities at the systems (elements), where the malfunction happened, if it does not cause any danger for lives of people and any serious development of the malfunction.

#### 9.6.12 Prior to start the committee functioning, NPP administration shall:

1) define the nature and scope of malfunction;

2) arrange call of the representatives from relevant organizations, if required;

3) take measures on keeping the diagrams of the recording devices, oscillograms, printouts, tape-recording of the operative communications, operative log-books;

4) record the values of the reactor neutron-physics characteristics, position of switchboards, cut-off and control valves, blinkers, overlaps during malfunctioning;

5) immediately after shift handing over, collect explanatory notes of the personnel involved into malfunction liquidation, its eye-witnesses, managers of the workshops;

6) based on available initial information, draw up the diagrams (in the unified time scale) of parameters variations at the malfunction occurrence and development required to analyze operation of systems (elements), where the notes on switchovers, activation of process protections and interlocks are made;

7) prepare the required design documentation, protocols of tests inspections, checks, circuits operating instructions;

8) prepare maintenance and repair documentation, as well as the information on previously occurred similar malfunctions at NPP.

#### 9.6.13 The internal and external emergency centers shall be established and equipped with the required equipment, devices and communication means, from which management by emergency plans implementation shall be performed in case of an accident.

# 10 TESTS AND CHECKS OF THE SYSTEMS AND EQUIPMENT DURING THE UNIT OPERATION

**10.1 General**

#### 10.1.1 This section defines the main methods, sequence, scope and periodicity of operational tests of the equipment, systems important to safety, as well as the main criteria at fulfillment of which the equipment is considered to be serviceable.

#### 10.1.2 The following types of the operational checks are not considered in this section:

1) the equipment metal control, hydraulic tests of the vessels and pipelines for tightness and strength and technical witnessing, which shall be performed as per special Rules and norms of the regulatory authority;

2) maintenance inspections and repairs of the equipment, which shall be performed as per the requirements of the design-and engineering and manufacturing documentation;

3) checks of the equipment, which shall be performed as per the Norms on the Equipment Testing.

#### 10.1.3 Readiness to functioning of the system equipment important to safety as well as the protections and interlocks shall be provided by a number of organizational and technical measures including:

1) testing schedules development and implementation;

2) development of programs for each type of tests;

3) arrangement and conduction of relevant personnel training;

4) recording of testing with analysis of the revealed comments;

5) restriction of the personnel access to the premises where SS equipment is located, to protection, interlock and control devices;

6) the Unit startup time schedules shall consider the time required for testing after SPM;

7) timely elimination of the revealed defects and damages;

8) recording PPI functioning time with analysis of the reasons for their malfunctioning;

9) sequence of work with the engineering station at simulation of signals of protections and interlocks;

10) fulfillment of testing sequence, requirements of the design-and engineering and manufacturing documentation.

**10.2 Scope and periodicity of the systems and equipment testing**

#### 10.2.1 Scope of testing the systems important to safety at the Unit startup is defined in Table 10.2.1.

#### During operation at power, the scope of periodic tests of the standby equipment and systems important to safety is defined in Table 10.2.2.

#### In the process of the Unit shutdown the tests and checks shall be performed as per Table 10.2.3.

* + - 1. Specific requirements to periodicity of tests and criteria of successful completion of tests of the systems important to safety for the start up and power operation modes during shutdown are defined in 52.BU.1 0.00.AB.WI.ATEX.010 «Schedule of tests and inspections of RP systems important to safety».

#### 10.2.2 Prior to the Unit changeover to the minimally-controlled level of power after refueling, after overhaul or mid-life repair, all tests and checks of the process equipment and systems important to safety shall be performed in the scope specified in Table 10.2.1.

#### 10.2.3 The scope and periodicity of testing the protections and interlocks during the Unit operation shall be defined by the special specification (schedule).

#### 10.2.4 The scope and periodicity of EPSS equipment tests and checks are defined as per the requirements of the manufacturing documentation for the electrical equipment, The Basic Rules for Nuclear Power Plant Safety Assurance, Operating and Maintenance Instructions at Nuclear Power Plants, as well as in compliance with the operating instructions which shall be observed during EPSS operation and repair and specified in Tables 10.2.1, 10.2.2, 10.2.3. Malfunctions revealed during EPSS tests and checks shall be eliminated, after that the repeated testing shall be performed in the full scope. Extraordinary checks of EPSS and its individual elements shall be performed:

1) after eliminating the defects effecting EPSS serviceability, occurred during operation;

2) prior the Unit startup from “cold” condition, in case of the Unit outage duration more than ten days (with SS mechanisms startup as per the sequential startup program, by the electric circuits de-energizing factor);

3) prior the Unit startup after SPM or overhaul (with SS mechanisms startup at availability of the process emergency signal).

#### 10.2.5 At the Unit startup, complex CPS check shall be performed:

1) of the automatic power controller APC;

#### 2) power unloading and limitation controller ROM;

#### 3) accelerated preventive protection facilities APP;

#### 4) EP, PP signals shaping units;

#### 5) CPS power supply units;

6) neutron flux control equipment units;

7) serviceability of CPS drives shall be checked;

8) the systems of CPS CR individual and group control shall be controlled, as well as CPS CR position control and monitoring systems, functioning of the individual and group control algorithms, CPS CR position control algorithms;

9) effect of the emergency and preventive protections to CPS CR shall be checked including check from EP and PP buttons at MCR and ECR.

Upon completion, CPS complex check shall be finalized by the record in “Log-book of Acts (reports)”.

#### 10.2.6 Check of ICDS serviceability in ICIS as a whole shall be performed every time upon reaching reactor power as 60 % of the nominal one after refueling and at least once per month during the reactor operation at power. TC individual characteristics, as well as coefficients of converting the measured signals to the physical values shall be entered to ICIS before MCL approaching.

#### 10.2.7 The confinement system shall be annually tested for tightness by pressure 0,18 MPa (1,836 kgf/cm2 excess).

#### After every irregular unsealing of the confinement system elements, after repair or replacement of elements effecting tightness and strength, the tests for tightness shall be performed by pressure 0,18 MPa (1,836 kgf/cm2 excess). The Unit operation is not allowed if the confinement system tightness does not correspond to the established requirements.

#### Local tests of the isolating valves on the rarefication support system and the confinement radioactive drain shall be performed prior to the confinement testing for tightness.

#### Express-trial of the pressurization loop by vacuumizing (rarefication value - (150÷275) Pa) using the exhaust ventilation system TL09 shall be performed after the Unit shutdown for SPM with repair of the pressurization loop elements, but not less than once per year and after each irregular unsealing of the containment.

Confinement testing for tightness shall be performed in compliance with the confinement testing programme of the confinement.

#### 10.2.8 If during operation activities on pipeline sections replacement have been performed, which can cause changes in the hydraulic characteristics of the emergency gas removal system discharge line from PRZ to the relief tank, the tests confirming design hydraulic characteristics of the pipeline as a whole shall be performed.

The factors, which can change hydraulic resistance coefficient of the pressure drop line, are as follows:

1) works related to replacement of the valves or their repair;

2) replacement of the pipeline sections.

#### 10.2.9 If during operation any activities have been performed related to PSD repair or activities on repair and replacement of supply and discharge pipelines sections, which can cause change of the design PRZ PSD flow-rate value, the tests shall be performed similar to those confirming design hydraulic characteristics of the pipeline as a whole.

#### Tests and checks of the protection system pipelines shall be combined with tests and checks of the primary circuit system and performed in the scope and with periodicity as per PNAEG-7-008-89 “Reactor power plants equipment and pipelines installation and safe operation code”.

#### 10.2.10 In the period of the Unit shutdown for refueling, the pressurizing system equipment shall be subjected to the maintenance inspection. Prior inspection, deactivation shall be performed, if required.

#### The maintenance inspection shall include visual inspection and metal control by non-destructive techniques.

#### Insulation resistance and TEH circuits resistance shall be measured. Insulation resistance shall be not less than 2,2 MOhm (for TEH unit) and 20 MOhm (for heaters). Resistance of TEH unit circuits shall be not more than 1,57 Ohm. PRZ maintenance shall be performed as per the requirements of the technical documentation.

#### All pressurizing system equipment shall be subjected to visual inspection, including spring suspensions, emergency ropes, supports, hydraulic snubbers. Purpose of visual inspection is to reveal possible defects, leakage and unsealing and check whether positions of supports, ropes, hydraulic snubber spring suspensions correspond to the requirements of the design documentation.

#### Periodically, at least once a year during refueling at cooled-down primary circuit, the following shall be performed at the reactor refueling:

1) for hydraulic snubbers – measurement of the stem drawn-out size from the fully drawn-in position;

2) for spring supports and suspensions – spring height measurement;

#### 10.2.11 If during operation any factors are revealed or occurred, which can cause deviation from the design value of the ECCS line hydraulic resistance coefficient, the tests shall be performed, to check and confirm design values of the coefficients.

#### ECCS passive part testing for checking serviceability of channels as a whole and defining hydraulic resistance coefficient of the lines hydraulic accumulator – reactor with boric acid solution flushing to the unsealed reactor at pressure in the hydraulic accumulators (1,76÷2,35) MPa ((18÷24) kgf/cm2) shall be performed:

1) after replacing the check valves Dnom 300;

2) after replacing the shutoff gate valves Dnom 300;

3) after repair activities on the check valves Dnom 300, shutoff gate valves Dnom 300 or pipelines Dnom 300, which can cause changes in ECCS line hydraulic resistance;

4) at pressure differential increasing over the permissible value required for opening the check valve.

#### 10.2.12 In the beginning of the fuel lifetime the following physical experiments shall be performed (list of tests may be supplemented):

1) at the minimally-controlled level of power the following shall be defined:

a) critical boric acid concentration in the primary circuit coolant;

b) reactivity coefficient by the boric acid concentration in the primary circuit coolant;

c) summary temperature coefficient of reactivity (by fuel and coolant temperature);

d) CPS CR operating group effectiveness.

2) at the reactor plant power level up to 1 % Nnom, the reactor EP effectiveness shall be measured (also without one the most effective CPC CR);

3) during all lifetime in the steady state at the nominal level of power the following shall be controlled and recorded in the electronic archive:

a) current boric acid concentration in the primary circuit coolant;

b) the reactor core peaking factors, linear power-flux by FE head;

c) reactor power defined by different ways;

d) control rods position.

#### As per obtained results, comparing of the design and restored power density fields shall be compared at least once a month.

* + - 1. 10.2.13 Scope of inspections of radiation monitoring systems is specified in Table 10.2.4.
      2. Specific requirements to periodicity of tests an criteria of successful completion of tests of radiation monitoring systems are defined in the APCS operating instruction.
      3. 10.2.14 For common-plant objects system of reliable power supply CPSDPP 10GY50 the below scope of inspections is set up based on the schedule approved in set up order:
      4. - when unit power operations the operability of diesel generator plant and auxiliary systems during its start up and acceleration to external grid shall be tested every month;
      5. - annually, before power unit start up after PPM with refueling, operability of the process systems and equipment shall be tested during integrated tests in the mode of de-energization of sections 10BK, 10BL , start up of diesel generator plant 10GY50 and multistage start up of mechanisms.

Table 10.2.1 – List of tests and checks of the systems and equipment important to safety to be performed during SPM and in the period of the Unit startup after refueling

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| No. | Test type | Conditions of testing | Periodicity of checks, terms of tests | Test successful completion criteria |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 1 | Emergency core cooling system (ECCS passive part) YT11,12,13,14B001 | | | |
| 1.1 | The system testing for tightness | At the section from the reactor up to valves YT11(12,13,14)S001 minimal ECCS pipelines temperature is 30°С within all service. Pressure at testing for tightness is 17,6 MPa  (180 kgf/cm2). At the section from the valves YT11(12,13,14)S001 up to the accumulator (including the accumulator), the minimal metal temperature is 30°С within all service. Pressure at testing for tightness is 6,7 MPa (68,34 kgf/cm2). ECCS HA SV are disabled. Keeping under pressure shall be within the time sufficient for inspection | After each unsealing | In the process of testing, no leakage of sealing joints were revealed during inspection. |

| Table 10.2.1, continued | | | | | | |
| --- | --- | --- | --- | --- | --- | --- |
| No. | Test type | Conditions of testing | Periodicity of checks, terms of tests | | Test successful completion criteria | |
| 1.2 | Hydraulic tests of ECCS accumulators and pipelines | At the section from the reactor up to valves YT11(12,13,14)S001 minimal ECCS pipelines temperature is 30°С within all service. Permissible limits of pressure fluctuation at hydraulic tests are 24,5-25 MPa (249,9 – 255 kgf/cm2). Inspection pressure is  19,6 MPa 200 kgf/cm2). At the section from the valves YT11(12,13,14)S001 up to the accumulator (including the accumulator), the minimal metal temperature is 30°С within all service. Pressure at hydraulic testing, permissible pressure fluctuations are 8,3±0,2 MPa (84,74±2,04 kgf/cm2). Inspection pressure is 6,7 MPa (68,34 kgf/cm2). ECCS HA SV are disabled. Keeping under pressure shall be within the time sufficient for inspection | At least once in four years or after every repair at which heating, welding or replacement of pressure-loaded parts took place | | In the process of testing and during inspection no metal leakage and breakage have been revealed, within 10 minutes keeping under pressure during hydraulic tests the pressure didn’t exceed the established limits, and after testing no residual deformations have been revealed | |
| 1.3 | Trial of ECCS hydraulic accumulators with flushing. Serviceability check of the electric circuits of check valves position signaling. Check for opening and closing by the fast-acting gate-valves setpoint. Serviceability check of SGV control, power, position signaling circuits from MCR and ECR. Serviceability check of bypass line valves position signaling circuits | Initial parameters in the reactor: temperature is 95-130 °С; pressure is 6,4-6,9 MPa (65 - 70 kgf/cm2); temperature in the accumulators not less than 55 °С. The accumulators are filled up to 6,3 m level, pressure is 5,88 MPa  (60 kgf/cm2), valves are closed | Once in four years or afterrepair performed on the check valves for one of the channels. For the other ECCS passive part channels, serviceability of the active elements shall be checked without water discharging to the reactor | | Gates of the check valves start opening at differential 0,029 MPa (0,29 kgf/cm2) on them. Check valve gates position signaling at MCR and ECR corresponds to the position of gates. Fast-acting isolation valves are closing upon reaching the setpoint for closing. Complete closing time is 10 sec. Valve gates position signaling at MCR and ECR corresponds to the position of gates. Electric-driven valves are controlled without comments. Valves signaling correspond to the actual position of the gates | |
| 1.4 | Check of SV activation pressure correspondence to the real pressure increasing | Accumulators are filled with water up to 6,3 m level, pressure 5,88 MPa (60 kgf/cm2), the valves are closed | Once a year during SPM with refueling. | | SV opening-closing pressure corresponds to the pressure values specified in the note. Permissible deviations from the defined values for the valve «opening-closing»: not more than 0,1 MPa (1,02 kgf/cm2). The gate position signaling is serviceable | |
|  | Note  1. It is allowed to test and adjust SV springs at pressure supplying from the portable pressure source (gas bottle) equipped with the reference manometer. Nitrogen is supplied via the adjustment valve, PV springs shall be adjusted as per the manufacturer instruction.  1.1 Pressure at the beginning of opening by the spring:  - check valve: 6,69 MPa (68,2 kgf/cm2)  - operating valve: 6,75 MPa (68,9 kgf/cm2)  1.2 Pressure of full opening by the spring  - check valve: 6,94 MPa (70,8 kgf/cm2)  - operating valve:7,0 MPa (71,4 kgf/cm2)  1.3 Pressure of closing by the spring  - check valve: 5,73 MPa (58,5 kgf/cm2)  - operating valve: 5,73 MPa (58,5 kgf/cm2)  2. The check as per item 1.4 is allowed to be performed at the certified test-rack | | | | | |
| 2 | Second stage ECCS hydraulic accumulators (ECCS passive part) TH16,17,26,27,36,37,46,47B001 | | | | | |
| 2.1 | The system testing for tightness | At the section from the reactor up to gate valves TH16(17,26,27,36,37,46,47)S001 minimal ECCS pipelines temperature is 30°С within all service. Pressure at testing for tightness is 17,6 MPa  (180 kgf/cm2). At the section from the gate valves TH16(17,26,27,36,37,46,47)S001 up to the accumulator (including the accumulator), the minimal metal temperature is 30°С within all service life. Pressure at hydraulic testing is 2,8 MPa (28,48 kgf/cm2). ECCS HA SV are disabled. Keeping under pressure shall be within the time sufficient for inspection | After each unsealing | | In the process of testing, no leakage of sealing joints were revealed during inspection. | |
| 2.2 | Hydraulic tests of ECCS accumulators and pipelines | At the section from the reactor up to gate valves TH16(17,26,27,36,37,46,47)S001 minimal ECCS pipelines temperature is 30°С within all service. Permissible limits of pressure fluctuation at hydraulic tests are 24,5-25 MPa (249,9 – 255 kgf/cm2). Inspection pressure is  19,6 Mpa (200 kgf/cm2). At the section from the gate valves TH16(17,26,27,36,37,46,47)S001 up to the accumulator (including the accumulator), the minimal metal temperature is 30°С within all service life. Pressure at hydraulic testing, permissible pressure fluctuations are 3,125±0,2 MPa (31,9±2,04 kgf/cm2). Inspection pressure is 2,24 MPa (22,9 kgf/cm2). ECCS HA SV are disabled. Keeping under pressure shall be within the time sufficient for inspection | At least once in four years or after every repair at which heating, welding or replacement of pressure-loaded parts took place | | In the process of testing and during inspection no metal leakage and breakage have been revealed, within 10 minutes keeping under pressure during hydraulic tests the pressure didn’t exceed the established limits, and after testing no residual deformations have been revealed | |
| 2.3 | Trial of ECCS hydraulic accumulators with flushing. Serviceability check of the electric circuits of check valves position signaling. Serviceability check of SGV control, power, position signaling circuits from MCR and ECR. Serviceability check of bypass line valves position signaling circuits | Initial parameters in the reactor: temperature is less than 85 °С; pressure is 1,5-1,8 MPa (15 - 18 kgf/cm2); the accumulators are filled up to the nominal level, pressure is 2,45 MPa  (25 kgf/cm2), the valves are closed | Once in four years or afterrepair performed on the check valves for two channels. For the other ECCS passive part channels, serviceability of the active elements shall be checked without water discharging to the reactor | | Gates of the check valves start opening at differential 0,029 MPa (0,29 kgf/cm2) on them. Check valve gates position signaling at MCR and ECR corresponds to the position of gates. Valve gates position signaling at MCR and ECR corresponds to the position of gates. Electric-driven valves are controlled without comments. Valves signaling correspond to the actual position of the gates. | |
| 2.4 | Check of SV activation pressure correspondence to the real pressure increasing | The accumulators are filled up to the nominal level, pressure is 2,45 MPa (25 kgf/cm2), valves are closed | Once a year during SPM with refueling. | | SV opening-closing pressure corresponds to the pressure values specified in the note. Permissible deviations from the defined values for the valve «opening-closing»: not more than 0,1 MPa (1,02 kgf/cm2). The gate position signaling is serviceable | |
|  | Note  1. It is allowed to test and adjust SV springs at pressure supplying from the portable pressure source (gas bottle) equipped with the reference manometer. Nitrogen is supplied via the adjustment valve, PV springs shall be adjusted as per the manufacturer instruction.  1.1 Pressure at the beginning of opening by the spring:  2,88 MPa (29,38 kgf/cm2)  1.2 Pressure of full opening by the spring:  2,93 MPa (29,54 kgf/cm2)  1.3 Pressure of closing by the spring:  2,43 MPa (24,45 kgf/cm2)  2. The check as per item 2.4 is allowed to be performed at the certified test-rack | | | | | |
| 3 | Primary circuit overpressure protection system YP21,22,23S001 | | | | | |
| 3.1 | PSD and control circuits serviceability check with MV actuation form CK. | Reactor is in sub-critical condition,  СН3ВО3 – not less than 16 g/dm3,  Т1к=(260÷280) °С  Р1к=144 kgf/cm2 (13,7 MPa),  Steam blanket is in PRZ, НPRZ=8500 mm,  Two RCPS are in operation. | Prior the Unit startup after refueling. | | MV YP21,22,23S001 are serviceable at opening from CK, PPD and ACL valves signalization is serviceable. MV opening time from the signal generation moment is not more than 1 sec. | |
| 3.2 | Check of PV springs adjustment from outside pressure source without MV actuation (at closed COV). | Reactor is in sub-critical condition,  Н3ВО3 concentration is not less than 16 g/dm3,  Тpc=(250÷270) °С  Рpc=125 kgf/cm2 (12,25 MPa), steam blanket in PRZ,  Нprz=8000 mm, at least two RCPS are in operation. | Once in 2 years during the Unit heat-up after preventive maintenance. | | PV springs adjustment pressure corresponds to the design one  PV and COV signalization is serviceable. | |
| 3.3 | Check of PSD control circuits and COV interlock. | Reactor is in sub-critical condition,  Н3ВО3 concentration is not less than 16 g/dm3,  Тpc=(20÷60) °С;  Рpc - not more than 35 kgf/cm2 (3,43 MPa). | Prior the Unit startup after preventive maintenance. | | PV, ACL and COV control circuits are serviceable and functioning from CK and at supply of calibrating current signals from PPD PV test benches. At generation of two signals: "PV is open" and "current" signal Рpc=155 kgf/cm2 (15,19 MPa) COV shall be actuated. | |
| 3.4 | Check of PV functioning without MV actuation from CK from MCR and ECR. | Reactor is in sub-critical condition,  Boric acid concentration is not less than 16 g/kg. Тpc=(260÷280) °С. Рpc= 144 kgf/cm2 (13,7 MPa). Steam blanket in PRZ, Нprz=8500 mm.  At least two RCPS are in operation. | Once a year at the Unit heat-up after preventive maintenance. | | PV YP21,22,23S002,003 are serviceable from CK from MCR and ECR. Signalization is serviceable. At closed cut-off valve MSV does not open. | |
| 3.5 | Check of ACL valves from MCR and ECR without MV actuation. | At nominal primary circuit parameters. | Once in six months. | | ACL valves are serviceable from CK from MCR and ECR. Signalization is serviceable. | |
| 3.6 | PSD check by actual pressure increasing. | Reactor is in sub-critical condition,  Boric acid concentration is not less than 16 g/kg 3. Тpc=(270÷280) °С. Рpc=(160÷190) kgf/cm2 ((15,7÷18,6)MPa) | Prior cool-down at shutdown for preventive maintenance. Each PPD shall be checked once in three years. | | PV and main safety valve opening and closing pressure corresponds to the design values. PPD valves signalization is serviceable. | |
|  | ACL – additional control line | | | | | |
| 4 | Pressuring system YP | | | | | |
| 4.1 | PRZ system tests for tightness | PRZ system tests for tightness shall be performed within RP primary circuit at the sub-critical reactor. The condition of the system and equipment as a whole is as per operating instruction for RP and the operating instruction for the primary circuit equipment. Test pressure is 17,6±0,5 MPa (179,52±5,1 kgf/cm2). Minimal temperature of PRZ vessel surface is 75 °С within all service life | After each unsealing | | During testing and inspection no leakage have been revealed | |
| 4.2 | PRZ system hydraulic tests | PRZ system hydraulic tests (up to PPD) shall be performed within RP primary circuit at the sub-critical reactor. The condition of the system and equipment as a whole is as per operating instruction for RP and the operating instruction for the primary circuit equipment. Hydraulic test pressure is from 24,5 to 25 MPa (from 249,9 to 255 kgf/cm2). Inspection pressure is from 19,6 to 20,6 MPa (from 199,92 to 210 kgf/cm2). Minimal temperature of PRZ vessel surface is 75 °С within all service life | At least once in four years or after every repair at which heating, welding or replacement of pressure-loaded parts took place | | In the process of testing and during inspection no metal leakage and breakage have been revealed. In the process of keeping under pressure, the pressure differential does not exceed the established limits, and after testing no residual deformations have been revealed | |
| 4.3 | Hydraulic tests of the relief tank with the discharge pipeline section up to PRZ PSD | The relief tank is fiiled with water, air is completely removed from it; the relief tank I&C are activated; instead of rupture membranes the cap are installed. The reactor is in sub-critical state. Primary circuit pressure is not less than 1,47 MPa (15 kgf/cm2). The relief tank walls temperature is not less than 20 °С within all service life. Hydraulic testing pressure is 0,98 MPa (10,0 kgf/cm2). Inspection pressure is 0,79 MPa (8,0 kgf/cm2) | Once in eight years | | In the process of testing and during inspection no metal leakage and breakage have been revealed, in the process of keeping under pressure, the pressure did not exceed the established limits, and after testing no residual deformations have been revealed | |
| 4.4 | PRZ system equipment displacement control during heat-up process | The reactor is in sub-critical state. Primary circuit pressure is within the range  20-290 °С | At each heat-up | | Displacements of hydraulic snubber stems are in compliance with the schedules «Thermal displacements» obtained during the Unit commissioning and included to RP operation manual | |
| 4.5 | Serviceability check of PRZ system valves | The reactor is in sub-critical state, nitrogen blanket in PRZ, primary circuit pressure is 1,9 MPa (19,38 kgf/cm2) | At each preparation for startup | | The electric-driven valves are serviceable, valve gates position signalization is serviceable | |
| 4.6 | Check of PRZ TEH sets activation (turning-on and off by pressure at the reactor top) | The reactor is in sub-critical state, H3BO3 concentration is 16- 20 g/dm3,  Тpc=260-290 ºС,  Тprz – corresponds to saturation temperature (346 °С)  at , Рpc=15,39÷15,78 MPa (157÷161 kgf/cm2),  Нprznot less than 5700 mm | At each preparation for startup | | PRZ TEH sets are activated and tripped as per the defined setpoints | |
| 4.7 | Level controller serviceability check in the process of filling and heat-up. | The reactor is in sub-critical condition. Primary circuit is filled with water. Boric acid concentration is not less than 16 g/dm3. Primary circuit pressure -(20÷160) kgf/cm2 ((1,96÷15,7) MPa). Temperature at heat-up is within the range (20÷290) °С. | Each time at preparation for startup. | | Controller maintains the following level values:  at primary circuit equipment refilling - (11700±150) mm, at heat-up - (11200±150) mm. | |
| 4.8 | Manhole joints tightness control. | RP condition prior startup. | At each manhole sealing. | | Stud extraction value - (0,24±0,01) mm | |
| 4.9 | At primary circuit pressure regulator YPR10DP001, YPR10DP002 serviceability check,. | The reactor is in sub-critical condition,  СНзВОз – not less than 16 g/dm3,  Тpc=280 °С.,  Рpc=160 kgf/cm2 (15,7 MPa),  Steam blanket in PRZ,  ТPRZ=345,6°С,  НPRZ=8700 mm,  Four RCPS are in operation. | Prior the Unit startup after preventive maintenance. | | At pressure decreasing beyond the permissible limits, electric heaters groups shall be started up serially. At pressure increasing beyond the permissible level, valves at the injection line shall be opened. The regulator maintains primary circuit pressure at accuracy ± 1,5 kgf/cm2 (±0,15 MPa). | |
| 4.10 | Hydraulic snubbers position control. | The reactor is in sub-critical condition.  Primary circuit pressure is within the range of (20Q290 )°С. | Prior the Unit startup after preventive maintenance | | Displacements value differs from the design ones to not more than 10 mm. | |
| 4.11 | Measurement of TEH insulation resistance and electric resistance. | Reactor is in “cold” condition. PRZ level is not lower than 3500 mm. | Once a year or in case of water or boron solution ingress to the outer surface. | | TEH unit insulation resistance in cold condition shall be not less than 1 MOhm. | |
| 4.12 | Check of PRZ injection efficiency. Determination of PRZ pressure decreasing rate at operation of one or two PRZ injection lines. | The reactor is in sub-critical condition,  СНзВОз - not less than 16 g//kg,  Тpc=280 °С,  Рpc=160 kgf/cm2 (15,7 MPa), Steam blanket in PRZ,  ТPRZ=345,6°С,  НPRZ=8700 mm,  Four RCPS are in operation | Prior the Unit startup after preventive maintenance. | | Primary circuit pressure decreasing rate at operation of one or two PRZ injection lines shall be not less than -0,00673t+2,18 (kgf/cm2/sec), where t – injected water temperature (injection flow-rate 150 kg/sec). Actuation time YP11,12S002 – not more than 10 sec, | |
| 5 | The main circulating pipeline | | | | | |
| 5.1 | HT | At the complex testing within RP. MCP walls temperature > 60°С. Thermal insulation in places of welded joints is removed | Once in four years | | Absence of the metal leakage and breaks. Absence of visual residual deformations | |
| 5.2 | Tests for tightness | Within RP.  Thermal insulation is applied | Annually | | Absence of leakage | |
| 5.3 | Visual inspection of the check holes at the temperature measurement nozzles | Thermal insulation is removed | During HT | | Absence of boric acid leaks | |
| 5.4 | Control for thermal displacements | MCP is filled with water.  Primary circuit coolant temperature is 70-320°С | At each heat-up - cool-down | | Non-exceeding the check values | |
| 6 | Steam-generator with the supports YB10,20,30,40W001 | | | | | |
| 6.1 | Check of SG free movement capability, its rolling bearings and hydraulic snubbers due to thermal expansion of the pipelines and SG | Conditions of testing  At SG vessel temperature 20-50, 100, 200 and 278°С | After each SPM, in heat-up process | | Dependencies of SG free movement by readings of the each SG hydraulic snubber stem position sensors at primary circuit water temperature changing, shall coincide with the dependencies introduced to the operating instruction for RP as per the results obtained at the stage of commissioning and accepted as the basic dependencies | |
| 6.2 | Check the level meter readings for correctness | The secondary circuit is filed with water. Vessel temperature is 20-50°С, atmospheric pressure | At each SG filling | | Readings of the single-type level meters have difference within the measurement errors at one SG.  Maximally permissible value of the double-chamber level meter error is ±15 mm, for the single-chamber level meter it is ±75 mm | |
| 6.3 | SG hydraulic tests by the primary and secondary circuits | Pressures at SG hydraulic tests:  - by the primary circuit 24,5 MPa (250 kgf/cm2), the tests shall be performed within RP primary circuit;  - by the secondary circuit 10,8 MPa (110 kgf/cm2), the tests shall be preformed jointly with the secondary circuit pipelines.  Temperature at SG hydraulic tests:  - by the primary circuit 95-130 °С  - by the secondary circuit 90-130 °С.  At SG hydraulic testing by the secondary circuit, maintain pressure in the primary circuit as 12,3 MPa (125,5 kgf/cm2) | At SG technical witnessing, at lest once in four years | | In the process of testing and during inspection no metal leakage and breakage have been revealed. In the process of keeping under hydraulic testing pressure, the pressure shall be within the following limits:  - by the primary circuit 24,5-25,0 MPa (250-255 kgf/cm2);  - by the secondary circuit 10,8-11,3 MPa (110-115 kgf/cm2).  After testing no any visible residual deformations have been revealed | |
| 6.4 | SG tests for tightness by the primary and secondary circuits | Pressures at SG tests for tightness by the primary and secondary circuits:  - by the primary circuit 17,64 MPa  (180 kgf/cm2), the tests shall be performed within RP primary circuit;  - by the secondary circuit 7,84 MPa (80 kgf/cm2), the tests shall be preformed jointly with the secondary circuit pipelines.  Temperature at SG tests for tightness:  - by the primary circuit 95-120 °С  - by the secondary circuit 90-120 °С.  At SG tests for tightness by the secondary circuit, pressure in the primary circuit shall be higher than the secondary circuit pressure to not less than 1 MPa (10,2 kgf/cm2) | To be performed after each SG unsealing by the primary and secondary circuits or unsealing of the associated primary or secondary circuit equipment | | In the process of testing, no leakage of sealing joints were revealed during inspection | |
| 6.5 | Check for inter-circuit tightness | Tightness check of heat-exchanging tubes, primary circuit ISC and air removal lines shall be performed at shutdown SG.  Check for primary circuit flanged connections tightness shall be performed in heat-up process | Each time upon revealing leakage from the primary circuit to the secondary one by the primary circuit flanged connections, primary circuit ISC and air removal lines, heat-exchanging tubes, when the leakage value exceed one of the operational limits or safe operation limits recorded prior to SG shutdown. Operational limits:  - permissible value of the primary coolant leakage by individual SG is 4 kg/hr;  - permissible value of the reduced specific activity of isotope 131I in blow-down water from the «salt» chamber of each SG is 370 Bq/kg.  Safe operational limits:  - maximal value of the primary coolant leakage by individual SG is 5 kg/hr;  - maximal value of the reduced specific activity of isotope 131I in blow-down water from the «salt» chamber of each SG is 740 Bq/kg.  Operational limits by leakage in the primary circuit header flanged connections:  - SG operation at leakages through both gaskets is not allowed;  - at leaking of only one of the gaskets it is allowed to operate SG within 72 hr at RP power ≤100% Nnom. | | Detection of the defective places at the primary circuit flanged connections, heat-exchanging tubes, primary circuit ISC and air removal lines, repair of the defective places, muffling the heat-exchanging tubes at shutdown SG. Absence of leakages during RP startup after SG repair. | |
| 6.6 | Check of the secondary circuit flanged connections | Check of the secondary circuit flanged connections tightness shall be performed during hat-up process | Upon leakage revealing by the secondary circuit flanged connections.  Operational limits on secondary circuit hole Dу800 and manhole flanged connections leakages:  - at leaking of only inner gasket, SG operation is allowed at RP power ≤100% Nnom till the next SPM;  - SG operation with both gaskets leaking is allowed within 72 hr at RP power ≤100%, Nnom | | Detection of the defect on the secondary circuit flanged connections, repair of the defective places or replacement of the defective gasket at shutdown SG.  Absence of leakages at RP startup. | |
| 7 | Dynamic pipeline attachment system | | | | | |
| 7.1 | Check of the hydraulic snubers condition:  1. External HS inspection to reveal any damages of leakage.  2. Reliability of fastening HS, pots, connection tubes, position sensors, level sensors, cables.  3. Position sensor output resistance measurement.  4. Check of fluid level in the pot by the mechanical indicator.  5. Inspection of the hydraulic snubbers with their disassembly | RP is in в “cold” condition | Activities as per items 1-5 shall be performed during SPM with refueling.  Activities as per item 5 shall be performed once in 3 years with further check of HS characteristics at the test-rack. The testing results shall be introduced to the log-form. | | The condition is in correspondence with the design requirements | |
| 8 | Reactor YC10B001 | | | | | |
| 8.1 | The reactor hydraulic tests | The reactor hydraulic tests shall be performed within the reactor plant primary circuit at the sub-critical reactor | The hydraulic tests shall be performed at least once in four years | | In the process of testing and during inspection no metal leakage and breakage have been revealed. After testing no any visible residual deformations have been revealed | |
| 8.2 | The reactor testing for tightness | The reactor testing for tightness shall be performed within the reactor plant primary circuit at the sub-critical reactor | After each reactor sealing prior to its startup | | In the process of testing and during inspection there were no leakage of the reactor sealing joints | |
| 8.3 | Check of the reactor upper unit leakage alarm functioning | Check of the upper unit leakage alarm functioning shall be performed at the sub-critical reactor prior to starting heat-up and pressure increasing in the primary circuit. It is allowed to determine availability of the joint leaking by pressure drop, at UU mounted to its inspection cavity, prior to the reactor assembling | The check shall be performed after each reactor assembling, as well as after each joint sealing | | At checking UU nozzles flanged joints for tightness after supplying air to ISC of each joint at pressure from 0,45 to 0,55 MPa (from 4,6 to 5,6 kgf/cm2), pressure drop rate shall not exceed 0,2 MPa (2 kgf/cm2) per min. At checking leakage alarm activation after supplying air at pressure from 1,0 to 1,2 MPa (from 10,2 to 12,2 kgf/cm2) to each UU «rack» with the leakage alarm sensor, the leakage alarms at MCR shall be activated | |
| 8.4 | Check of the reactor main joint tightness | The check shall be performed at the sealed sub-critical reactor prior to start primary circuit pressure increasing by pressure supplying to ISC of the main joint | The check shall be performed after each reactor assembling | | The check is considered to be successful, if at water supplying to ISC at pressure 2,0 MPa (20,4 kgf/cm2), no pressure decreasing is observed within 10 minutes. | |
| 8.5 | Check of the CPS AR coupled drive characteristics | Test conditions are in compliance with the drive operation manual | Periodicity of testing are in compliance with the drive operation manual | | Test successful completion criteria are in compliance with the drive operation manual | |
| 8.6 | Reactivity coefficient determination by boric acid concentration in primary circuit coolant | At bringing to MCL, at MCL | Once at the beginning of the fuel cycle after preventive maintenance | | Reactivity coefficient value by boric acid concentration in the primary circuit coolant corresponds to the design one | |
| 8.7 | Determination of temperature reactivity coefficient (by fuel and coolant temperature) | At bringing to MCL, at MCL | Once at the beginning of the fuel cycle after preventive maintenance | | Value of temperature reactivity coefficient (by fuel and coolant temperature) corresponds to the design one | |
| 8.8 | Determination of CPS CR operating group efficiency | At bringing to MCL, at MCL | Once at the beginning of the fuel cycle after preventive maintenance | | Value of CPS CR operating group efficiency ) corresponds to the design one | |
| 8.9 | Measurement of reactor EP efficiency (without one the most effective CPC CR) | At bringing to MCL, at MCL | Once at the beginning of the fuel cycle after preventive maintenance | | Value of reactor EP efficiency (without one the most effective CPC CR) corresponds to the design one | |
| 9 | RCPS YD10,20,30,40D001 | | | | | |
| 9.1 | Check of protections and interlocks | RCPS is ready for startup | Prior to each RCPS startup after SPM | | Activation of protections and interlocks is provided as per the RCPS operation manual | |
| 9.2 | Hydraulic tests | General conditions are specified in the Operating Instruction for the primary circuit equipment. Stop valves on sealing water feeding line to RCPS are closed as well as the vent on sealing water removal line | To be performed at the primary circuit hydraulic testing, but at least once in four years | | Absence of leakages, wetting, visible residual deformations | |
| 9.3 | Test for tightness | General conditions are specified in the Operating Instruction for the primary circuit equipment. | To be performed at the primary circuit testing for tightness after each unsealing | | Absence of leakages in the flanges and joints | |
| 9.4 | Check of RCPS feeding | The check shall be performed at the reactor plant operation at power not less than 10 % Nnom | Annually after SPM and replacement of the removable part | | At any combinations of running RCPS, flow-rate shall be within 20000 to 27000 m3/hr | |
| 10 | Emergency gas removal system YR | | | | | |
| 10.1 | Serviceability check of valves | The check shall be conducted at filling the primary circuit prior to hydraulic testing. Primary circuit is sealed and filed with coolant to 0,2 m below the reactor main joint. The pressure is atmospheric | The check shall be performed at the scheduled shutdowns and after replacing the system elements | | The system valves are controlled without any comments:  - the stem motion is smooth;  - no shocks or vibration at its opening and closing;  - valves position as per signalization corresponds to it actual position | |
| 10.2 | Check of pipeline throughput capacity:  a) pipeline passability; | Primary circuit pressure 1,0 - 3,0 MPa  (10,2 – 30,6 kgf/cm2), Coolant temperature is not more than 90 °С | The check shall be performed at the scheduled shutdowns and after replacing the system elements | | Water level increasing in the relief tank at opening the corresponding valves | |
|  | b) pipeline FRC determination | Primary circuit pressure 1,0 - 3,0 MPa  (10,2 – 30,6 kgf/cm2), Coolant temperature is not more than 90 °С | After repair with replacement of the valves or pipeline elements (only for the pipelines subjected to repair) | | FRC corresponds to the design values. The procedure of determination is available in the working program. | |
| 10.3 | Hydraulic tests of the system pipelines from the reactor, SG and discharge pipelines «PRZ – PRZ PSD» up to valves  YR51,52S001  YR60S001,002  YR61,62S001 | The tests shall be performed within RP primary circuit:  - HT pressure is 24,5 MPa (250 kgf/cm2);  - inspection pressure is 19,6 MPa (200 kgf/cm2) | At least once in four years or after every repair at which heating, welding or replacement of pressure-loaded parts took place | | In the process of testing and during inspection no metal leakage and breakage have been revealed, in the process of keeping under hydraulic testing pressure, the pressure did not exceed the established limits, and after testing no residual deformations have been revealed | |
| 10.4 | Hydraulic testing of the system pipelines starting from valves YR51,52S001, YR60S001,002 YR61,62S001 up to discharge pipeline «PRZ PSD – relief tank» | The tests shall be performed jointly with the relief tank:  - HT pressure is 0,98 MPa (10 kgf/cm2);  - inspection pressure is 0,78 MPa (8 kgf/cm2) | At least once in eight years and after every repair at which heating, welding or replacement of pressure-loaded parts took place | | Ditto | |
| 10.5 | Check of the valves for tightness | Pressure is 15,7 MPa (160 kgf/cm2), Temperature is 95-130 °С | The check shall be performed each time after the scheduled shutdown and prior to startup | | The valves tightness is confirmed | |
| 11 | Emergency and scheduled cool-down system TH10,20,30,40 | | | | | |
| 11.1 | Serviceability check of the electric-driven system valves | RP condition is not stipulated | Once in 672 hours for each of four channels | | The design functioning of valves is confirmed | |
| 11.2 | Serviceability check of the pump units TH10,20,30,40D001 | RP condition is not stipulated | Once in 672 hours for each of four channels with simultaneous EPSS trial | | Serviceability of pumps is confirmed | |
| 11.3 | Check of the system channels effectiveness | 1. RP is in "cold" condition.  2. Primary circuit is sealed, temperature is less than 70 °С.  3. PRZ level is nominal.  4. НзВ0з concentration in the emergency storage tanks is not les than 16 g/dm3, chemical analysis meets the specification requirements. | Once in four years | | The pump supplies to primary circuit at pressure:  0,098 MPa (1 kgf/cm2) – not less than 750 m3/hr  0,98 MPa (10 kgf/cm2) - not less than 130 m3/hr | |
| 11.4 | Check of the check valves opening at the discharge pipelines | 1. RP is in "cold" condition.  2. Primary circuit is sealed, temperature is not less than 70 °С.  3. НзВ0з concentration in emergency boron storage tank is not less than 16 g/dm3, chemical analysis meets the specification requirements. | Once a year | | Pump supply to the primary circuit at pressure:  0,098 MPa (1 kgf/cm2) – not less than 750 m3/hr | |
| 12 | The containment spray system TJ | | | | | |
| 12.1 | Serviceability check of the electric-driven system valves | The reactor plant is in one of the following conditions:  - hot;  - the reactor is at MCL of power | Once in 672 hours for each of four channels | | The valves are controlled without comments | |
| 12.2 | Check with water-jet pumps flushing. | RP is cooled down | One channel shall be checked once in 4 years, during each preventive maintenance with refueling. | | Water-jet pump supply is not less than 10 m3/hr | |
| 12.3 | Check of passability of pipelines, sprinkler sprayers and check valves by the compressed air | RP condition is not scheduled | During preventive maintenance | | Passability of pipelines, sprinkler sprayers and the check valves is confirmed | |
| 13 | Extra borating system TW10,20,30,40 | | | | | |
| 13.1 | Serviceability check of the electric-driven system valves | RP is in the following condition: «hot»; « the reactor is at MCL of power».  TW system is in "Standby" mode | Once in 672 hours for each of four channels | | The design functioning of the electric-driven valves is confirmed | |
| 13.2 | Serviceability check of the pump units TW10,20,30,40D001 | RP is in the following condition: «hot»; «the reactor is at MCL of power».  TW system is in "Standby" mode | Once in 672 hours for each of four channels with simultaneous EPSS trial | | Serviceability of pumps is confirmed | |
| 13.3 | Check of the system channels effectiveness | 1. Primary circuit is sealed, primary circuit pressure is 15,7 MPa (160 кгс/cм2), Tpc=THT.  2. The level in the boric acid storage tanks is nominal | Once in four years | | Effectiveness of boron injection to the sealed primary circuit (of MCC loop) is confirmed, flow-rate at the pump head is not less than 2 kg/sec  (7,2 t/hr)).  Effectiveness of boron injection to the sealed primary circuit (to PRZ injection) is confirmed, flow-rate at the pump head is not less than 2 kg/sec (7,2 t/hr)) | |
| 13.4 | Check of check valves opening at the discharge pipelines | RP is in «hot» condition | Once a year | | Effectiveness of boron injection to the seated primary circuit (MCC loops) is confirmed, flow-rate at the pump thrust is not less than 2 kg/sec  (7,2 t/hr)).  Effectiveness of boron injection to the seated primary circuit (to PRZ injection) is confirmed, flow-rate at the pump thrust is not less than 2 kg/sec (7,2 t/hr)) | |
| 14 | Emergency boron injection system TH15,25,35,45 | | | | | |
| 14.1 | Serviceability check of the system electric-driven valves | RP is in the following condition: «hot»; « the reactor is at MCL of power».  TH system is in "Standby" mode | Once in 672 hours for each of four channels | | | Serviceability of the mechanical part of the electric-driven valves is confirmed |
| 14.2 | Serviceability check of the system pump units TH15,25,35,45D001 | RP is in the following condition: «hot»; « the reactor is at MCL of power».  TH system is in "Standby" mode | Once in 672 hours for each of four channels with simultaneous EPSS trial | | | Serviceability of the pump units at functioning by recirculating and testing line is confirmed.  Serviceability of the pump control and signaling circuits is confirmed |
| 14.3 | Tests of the system channels effectiveness, check of check valves opening at the discharge pipelines | The measures on the Unit startup shall be taken after refueling completion.  The primary and secondary circuit hydraulic tests have been performed.  TH system is ready for changeover to «Standby» mode | In the period of the Unit shutdown for SPM or prior to the Unit startup after SPM with refueling.  Testing in the period of the unit shutdown for SPM may be performed, if during SPM the overhaul or technical witnessing of the pump are not scheduled, at the same time, it is allowed not to perform the tests prior to the Unit startup | | | The pump supplies to primary circuit at pressure:  0,098 MPa (1 kgf/cm2) – not less than 240 m3/hr  7,2 MPa (73,4 kgf/cm2) - not less than 28 m3/hr |
| 14.4 | Check of the system check valves tightness | RP is in the following condition: «hot»; « the reactor is at MCL of power».  TH system is in "Standby" mode | At the Unit startup after SPM, or in case of the check valves repair during SPM | | | Tightness of the system check valves is confirmed |
| 15 | Emergency feed water system RS | | | | | |
| 15.1 | Serviceability check of the electric-driven valves | The reactor plant is in one of the following conditions:  - hot;  - the reactor is at MCL of power | Once in 672 hours for each of four channels | | | The design functioning of the electric-driven valves is confirmed |
| 15.2 | Serviceability check of the pump units by trial line RS12,22,32,42D001 | The reactor plant is in one of the following conditions:  - hot;  - the reactor is at MCL of power | Once in 672 hours for each of four channels with simultaneous EPSS trial | | | Serviceability of pump units RS12,22,32,42D001 at functioning by recirculating line is confirmed.  Serviceability of the pump control and signaling circuits is confirmed  Vibration speed value shall not exceed:  on the pump bearing bodies - 7.1 mm/sec,  on the motor bearing bodies - 4.5 mm/sec,  in frequency range - (10÷1000) Hz |
| 16 | VE – service water supply system for cooling TF and VJ intermediate circuits | | | | | |
| 16.1 | Serviceability check of the system electric-driven valves | RP condition is not regulated | Once in 672 hours for each of four channels | | | The design functioning of the valves is confirmed |
| 16.2 | Serviceability check of the pump units VE11,21,31,41D001 | RP condition is not regulated | Once in 672 hours for each of four channels with simultaneous EPSS trial | | | Serviceability of pump units is confirmed |
| 17 | Reactor building intermediate circuit cooling water system TF | | | | | |
| 17.1 | Serviceability check of the system pump units | The reactor plant is in one of the following conditions:  - hot;  - the reactor is at MCL of power | Once in 672 hours for each of four channels with simultaneous EPSS trial | | | Serviceability of pump units TF10(20,30,30,40)D001, TF21(31)D001 is confirmed  Serviceability of the pump control and signaling circuits is confirmed  Vibration speed value shall not exceed:  on the pump bearing bodies - 7.1 mm/sec,  on the motor bearing bodies - 4.5 mm/sec,  in frequency range - (10÷1000) Hz |
| 17.2 | System electric-driven valves serviceability check | RP condition is not scheduled | Once in 672 hours for each channel | | | Design functioning of the valves is confirmed |
| 18 | Emergency power supply system for the second reliability group consumers | | | | | |
| 18.1 | Complex testing of DG with actuation of the mechanisms on house-load de-energizing at availability of the emergency process signal | RP is sub-critical.  At Рpc – (11,76÷15,7) MPa (120÷160) kgf/cm2 | After primary circuit HT | | | 1. Voltage recovery time at the sections is not more than 15 sec after DG activating signal generation.  2. DG serviceability check  3. At load connection as per automatic program, the voltage decreasing is not less than 0,8 from the nominal one.  4. Check for correction of the mechanisms activation by steps as per the sequential startup algorithm.  5. Serviceability check of the activated units |
| 18.2 | Complex testing of DG with actuation of the process mechanisms by house-load de-energizing factor | RP is sub-critical and the Unit condition is relevant ("cold", "hot" etc.) | Once in 672 hours for each of four EPSS channels | | | Ditto |
| 18.3 | DG testing under the nominal load at connection in parallel to the network | RP is sub-critical and in "cold" condition | During commissioning | | | During operation at nominal power, the parameters of the main and auxiliary DG equipment corresponds to the technical conditions for the unit |
| 19 | Emergency power supply system for the first reliability group consumers | | | | | |
| 19.1 | Inspection of the storage batteries | RP is sub-critical | Every 6 months  once a year  once a year | for selected elements  for all elements during SPM | | Electrolyte temperature  Electrolyte density  Voltage  Temperature |
| 19.2 | Check discharging of the storage batteries | RP is in refueling mode | As per the manufacturer instruction | | | SB capacity adjusted to temperature 20 °С is not less than 80% of the nominal capacity |
| 19.3 | Serviceability confirmation for UPS connected by the regular circuit and its components | RP is sub-critical | Upon SPM completion (it is allowed to combine testing with trial of the channels) | | | The readings during testing correspond to the norm in compliance to the technical specification |
|  | Check of SB-supplied UPS operation (short-time UPS tripping at the a.c. side) |  |  | | |
| 19.4 | Complex testing of first group EPSS | RP is in refueling mode, in "cold" condition | During SPM within the terms established by the "Operating Instruction at NPP" | | | 1. First group EPSS algorithm corresponds to the design one.  2. First group EPSS equipment have no failures and malfunctions in operation caused by the testing modes.  3. During short-circuit test, UPS operation algorithm jointly with 1 group switchgears corresponds to the design |
| 19.5 | First group EPSS trial | RP is in refueling mode | Upon SPM completion | | | 1. First group EPSS algorithm corresponds to the design one.  2. UPS units protection setpoints correspond to the design. Rate of voltage fluctuations at the output does not exceed the permissible value.  3. At he maximal load-on and off, SHW output linear voltage deviations are within the permissible limits.  4. Voltage at DCB buses does not decrease below the permissible value |
| 20 | Safety-related consumers closed circuit system VJ | | | | | |
| 20.1 | Serviceability check of pump units VJ11,21,31,41D001 | RP is in following condition: «hot»; «the reactor is at ML of power».  VJ system is ready for operation.  RP is in "cold" shutdown condition:  - primary coolant temperature is not more than 70 0С.  VJ system is ready for operation | At each check for the diesel-generator serviceability and prior to the Unit startup after SPM completion | | | Serviceability of the pump unit control and instrumentation circuits is confirmed |
| 20.2 | System electric-driven valves serviceability check | RP condition is not scheduled | Once in 672 hours for each channel | | | Design functioning of the valves is confirmed |
| 21 | Emergency fire protection system (UX,UJ) | | | | | |
| 21.1 | Check of pumps UJ01,02,03,0405,07D001 and valves | RP is in "cold" condition | Once in 672 hours for each pump | | | 1. Pump unit parameters during functioning are in compliance with TU for the pump unit .  2. The valves are controlled from MCR without comments |
| 21.2 | Tests after pipeline rinsing and cleaning off the dirt and corrosion | RP is in "cold" condition | Once in 5 years for each pipeline section | | | In the process of testing and during inspection no metal leakage and breakage have been revealed, in the process of keeping under hydraulic testing pressure, the pressure did not exceed the established limits, and after testing no residual deformations have been revealed |
| 21.3 | Complex serviceability check of the spray fire-fighting systems for activation by annunciators | RP is in "cold" condition | Once in 3 years for each system section | | | The system response time and pressure at the beginning and at the end of functioning sprinkler rows correspond to those established in the testing program |
| 22 | Main steam-line system RA | | | | | |
| 22.1 | Check of SG PPD MK functionality from the pressure gauges | "Cold" condition | During SPM with refueling after SG PPD repair works completion | | | Serviceability of SG PPD MK is confirmed by signals from pressure gauges in all combinations of circuit 2 of 4.  Serviceability of SG PPD MK position signaling and control circuits is confirmed |
| 22.2 | Serviceability check of SG PPD | Transient condition:  The reactor heat-up from cold condition up to hot condition temperature at the Unit startup after the core refueling. | Prior to the Unit startup after SPM with refueling | | | Readiness of SG PSD for functioning by direct purpose is confirmed.  Serviceability of SG PSD position signaling and control circuits is confirmed |
| 22.3 | Check of SG PSD RA10÷40S001,002 activation by medium effect setting | «hot» condition | 1. Prior to the Unit startup after SPM with refueling.  2. After repair works at SG PSD, causing changes in adjustment parameters | | | Serviceability and design parameters of SG PSD adjustment are confirmed  Serviceability of SG PSD position signaling is confirmed |
| 22.4 | Check of MSIV RA10,20,30,40S004 serviceability | "Cold" condition | Prior to the Unit startup after SPM with refueling. | | | Readiness of MSIV to functioning by its direct purpose is confirmed;  Serviceability of MSIV position signaling and control circuits is confirmed;  The design requirement to MSIV closing time is confirmed |
| 22.5 | Check of BRU-A RA10÷40S003 serviceability | Transient condition:  The reactor heat-up from cold condition up to hot condition temperature at the Unit startup after the core refueling | Prior to the Unit startup after SPM with refueling | | | Readiness of BRU-A to functioning by its direct purpose is confirmed.  Serviceability of BRU-A position signaling and control circuits is confirmed.  The design requirement to BRU-A opening (closing) time is confirmed |
| 23 | CPS CR | | | | | |
| 23.1 | Check of CPS CR drop time | RP is in hot condition (4 RCPS) | Prior to beginning and upon expiration of the fuel lifetime | | | CPS CR drop time is within (1,2Q4) sec. |
| 24 | In-core instrumentation system ICIS | | | | | |
| 24.1 | Serviceability check of ICIS measurement channels with ICDS | RP is sub-critical. In the process of heat-up | After SPM, prior to the reactor approaching of power after SPM with refueling | | | The condition corresponds to the design requirements |
| 25 | Confinement system | | | | | |
| 25.1 | Complex testing of the isolating valves | RP - “cold” condition.  Pressure in the compressed air system is nominal | The tests shall be performed in the full scope prior to the Unit startup after SPM | | | 1. The valves are controlled from MCR I&C without comments. |
| 25.2 | Local tests for tightness of process penetrations, locks and hatches | RP - “cold” condition. Primary circuit is filled.  Service air system is ready for operation | In compliance with the design documentation | | | In compliance with the design documentation requirements |
| 25.3 | Confinement testing for integral leakage | RP - “cold” condition. Primary circuit is filled. The compressor plant and recording system are ready for operation. Рtest.= .= 0,18 MPa (1,836 kgf/cm2) (excessive) | After SPM with refueling | | | Relative leakage does not exceed 0,25 % of air volume inside the containment per day at maximal pressure under containment |
| 25.4 | Confinement testing shall be performed in compliance with the Confinement Operation Manual АМЕ 006.00.00.000RE. |  |  | | |  |
| 26 | Emergency control room (ECR) | | | | | |
| 26.1 | Check of control by the equipment and valves from ECR | RP is in “cold” condition | At startup of the equipment and valves controlled from ECR | | | The equipment is controlled from ECR without comments |

Table 10.2.2 – List of periodical tests and checks of the systems and equipment important to safety to be performed at the reactor operation at power

| No. | Test type | Condition of testing | Periodicity of checks terms of tests | Test successful completion criteria |
| --- | --- | --- | --- | --- |
| 1 | Emergency core cooling system (ECCS passive part) YT11,12,13,14B001 | | | |
| 1.1 | Control of leakages through check valves | The reactor operates at power. It can be preformed at the shutdown reactor at nominal parameters | Once in six months | Absence of level increasing in ECCS accumulator within 12 hr for each channel |
| 1.2 | Check of interlock by way of signals simulation with actual displacement of valves and checking their quick-action | The reactor operates at power.  Simultaneous check of two and more shutoff gate valves is forbidden | At least once a month | Closing of the shutoff gate valves with disabling of their opening is started at level simulation as per the setpoints. The time of the valves full opening is not more than 10 sec |
| 1.3 | Check of valves YT11(12,13,14)S001 YT11(12,13,14)S002 control circuits from MCR, ECR | The reactor operates at power.  Simultaneous check of two and more shutoff gate valves is forbidden | Once in six months | The valves are controlled from MCR, ECR |

| Table 10.2.2, continued | | | | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| No. | Test type | Condition of testing | | Periodicity of checks terms of tests | | Test successful completion criteria | | |
| 2 | Steam-generator with the supports YB10,20,30,40W001 | | | | | | | |
| 2.1 | Check of the level meter readings for correctness | Primary circuit pressure is 15,7MPa  (160 kgf/cm2),  Secondary circuit pressure is 6,28 MPa (64 kgf/cm2),  Secondary circuit temperature is 278,5 °С | | After SPM, CPW, repair activities at the level metering systems. At any steam capacity, once a week, by way of comparing of all level meters readings, in case of any suspicions in malfunctioning of one or several level meters at SG functioning with any capacity | | Reading of level meters at each SG are within Нnom±50 mm.  Readings of single-type level meters have difference within the measurement errors at one SG.  Maximally permissible error value for the double-chamber level meter is ±15 mm, single-chamber level meter - ±75 mm | | |
| 2.2 | Check of inter-circuit tightness | Primary circuit pressure is 15,7MPa (160 kgf/cm2),  Secondary circuit pressure is 6,28 MPa (64 kgf/cm2),  Secondary circuit temperature is 278,5 °С | | Take samples of the primary circuit coolant and blow-down water from the «salt» chamber of each SG once a week at one and the same moment of time. Define the specific activity of the reference radioactive nuclides: 131I, 132I, 133I, 24Na, 42K in the taken samples and by their values perform point estimation of leakage value for each SG.  Delete the text: Take blow-down water samples from the «salt» chamber of each SG once a day to define summary specific activity by «solid» residue | | Determination of the primary circuit coolant leakage to the secondary circuit and specific activity of isotope 131I in SG blow-down water.  Operational limits:  - Permissible value of the primary circuit coolant leakage by individual SG is 4 kg/hr;  - permissible value of the reduced specific activity of isotope 131I in blow-down water from «salt» chamber of each SG is 370 Bq/kg.  Safe operational limits:  - maximal value of the primary circuit coolant leakage by individual SG is 5 kg/hr;  - maximal value of the reduced specific activity of isotope 131I in blow-down water from «salt» chamber of each SG is 740 Bq/kg.  At exceeding one of the operational limits or safe operation limits, the Unit shall be changed over to «cold» condition to perform works on revealing and elimination of leakage or reasons for increasing of radioactive nuclides content in SG water | | |
| 2.3 | Check of SG blow-down water flow-rates by blow-down lines | Primary circuit pressure is 15,7MPa (160 kgf/cm2),  Secondary circuit pressure is 6,28 MPa (64 kgf/cm2),  Secondary circuit temperature is 278,5 °С | | SG blow-down at normal operation conditions:  - continuous blow-down from «salt» chambers is constant from all four SG;  - periodical blow-down of one SG through nozzles at SG body and nipples of the header “reservoirs”. Periodical blow-down is possible both simultaneously from all nozzles and nipples, and by each individually. Periodicity of activation and duration of the periodical blow-down shall be defined by the results of works performed as per SG blow-down adjustment program at the stage of commissioning .  - at blow-down water quality deviation from WC requirements, blow-down from «salt» chamber of the relevant SG is increasing | | Flow-rate of continuous blow-down is 15 t/hr from each SG.  Periodical blow-down is 30 t/hr from one SG .  At blow-down water quality deviation from WC requirements, blow-down from «salt» chamber of the relevant SG is increasing to 45 t/hr.  Total blow-down water flow-rate from all four SG in periodical blow-down mode is 60 t/hr | | |
| 2.4 | Check of primary and secondary circuit flanged connections tightness | Primary circuit pressure is 15,7MPa (160 kgf/cm2),  Secondary circuit pressure is 6,28 MPa (64 kgf/cm2),  Secondary circuit temperature is 278,5 °С | | Every shift | | Absence of pressure in inter-sealing caves.  In case of flanged connection integrity loss, the operational limits are as follows:  - It is not allowed to operate SG at leakages through both gaskets of the primary header flanged joints;  - if integrity of only one primary header flanged joints gasket is lost, SG operation is allowable within 72 hr at RP power ≤100%Nnom;  - At loosing the integrity of only inner gasket of secondary circuit hatch Dу800 and manhole flanged joints, SG operation is allowed at RP power ≤100% Nnom till the next SPM;  - SG operation with both gaskets of secondary circuit hatch Dу800 and manhole flanged joints leaking is allowed within 72 hr at RP power ≤100%, Nnom | | |
| 2.5 | Steam moisture check | Primary circuit pressure is 15,7MPa (160 kgf/cm2),  Secondary circuit pressure is 6,28 MPa (64 kgf/cm2),  Secondary circuit temperature is 278,5 °С;  The reactor power is nominal | | The tests shall be performed at commissioning and in case of SG reconstruction | | Steam moisture at SG outlet is not more than 0,2 % at the nominal SG water level | | |
| 2.6 | Operative SG level check | Primary circuit pressure is 15,7MPa (160 kgf/cm2),  Secondary circuit pressure is 6,28 MPa (64 kgf/cm2),  SG capacity is 100% | | At exceeding the permissible error values in the single-type level meters readings | | The double-chamber level meter readings error at «cold» bottom is not more than ±15 mm, single-chamber ones not more than ±75 mm.  Level meters readings at each SG are within Нnom ±50 mm.  Sodium concentration in the top and bottom sampling of the operative level metering sensor at operative SG level check:  - in the sample from the upper sampler it is within flame-photometer sensitivity limits (2-3 mkg/kg);  - in the sample from the bottom sampler it is within the norms for blow-down water from «salt» chamber (≤100 mkg/kg) | | |
| 2.7 | SG separation tests | Primary circuit pressure is 15,7MPa (160 kgf/cm2),  Secondary circuit pressure is 6,28 MPa (64 kgf/cm2),  SG capacity is 100% | | At upgrading of in-vessel devices, PDL reconstruction | | Determination of the nominal level value in SG and confirmation of the steam moisture design value as not more than 0,2% at the SG outlet at nominal water level in it and RP nominal power | | |
| 3 | Reactor YC10B001 | | | | | | | |
| 3.1 | Check of CPS CR mismatching | The check shall be performed for the control groups at the reactor operation at power | | The check shall be performed continuously by GICC equipment and in automated mode | | CR is considered as matched, if its position by height does not differ from all group position to more than 3 pitches as per readings of its position indicator | | |
| 3.2 | Testing (breakaway) of CPS drives of EP groups and control groups being at ULS by shifting to 2-3 steps down from ULS and back | RP at power | | At least once in a month | | Unavailability of comments on displacement of a bar with CPS AR | | |
| 4 | Emergency gas removal system YR | | | | | | | |
| 4.1 | Check of valves position by signaling at MCR and ECR | RP is at power | | At MCR – continuously, At ECR – periodically, as per the operating instructions | | Valves positions by signalization at MCR, ECR are without comments | | |
| 5 | TH system, emergency and scheduled cool-down group TH10,20,30,40 | | | | | | | |
| 5.1 | Check of pumps and valves from CK at MCR, ECR. | | RP is at power.  Check time shall be defined by parameters stabilization time, but not less than 30 minutes. | From MCR CK:  Pumps – once a month. Valves – once in 3 months  From ECR CK:  Pumps - once in 6 months Valves - once in 6 months | | 1. Pump unit parameters at operation by recirculation line – in compliance with TR for the unit.  2. Valves is controlled from MCR, ECR CK without comments. | | |
| 5.2 | Serviceability check of the pump units TH10,20,30, 40D001 | | RP is at power | Once in 672 hours for each of four channels with simultaneous EPSS trial | | Design functioning of the pump units by recirculation line is confirmed | | |
| 6 | The containment spray system TJ | | | | | | | |
| 6.1 | Check of the electric-driven system valves serviceability | | RP is at power | | Once in 672 hours for each of four channels | | | The valves are controlled without comments |
| 7 | Second stage ECCS hydraulic accumulators TH16,17,26,27,36,37,46,47B001 | | | | | | | |
| 7.1 | Check of valves TH16(17,26,27,36,37,46,47)S001,002 control circuits from MCR, ECR | | Operation at power. Simultaneous check of two and more gate valves is forbidden | | Once in six months | | | The valves are controlled from MCR, ECR |
| 8 | The extra borating system TW | | | | | | | |
| 8.1 | Check of pumps and valves from CK at MCR, ECR. | RP is at power.  Check time shall be defined by parameters stabilization time, but not less than 30 minutes. | | From MCR CK:  Pumps – once a month. Valves – once in 3 months  From ECR CK:  Pumps - once in 6 months Valves - once in 6 months | | 1. Pump unit parameters at operation by recirculation line – in compliance with TR for the unit.  2. Valves is controlled from MCR, ECR CK without comments. | | |
| 8.2 | Serviceability check of the system pump units TW10,20,30,40D001 | RP is at power | | Once in 672 hours for each of four channels with simultaneous EPSS trial | | Design functioning of the pump units by recirculation line is confirmed | | |
| 9 | Emergency boron injection system TH15,25,35,45 | | | | | | | |
| 9.1 | Check of pumps and valves from CK at MCR, ECR. | | RP is at power.  Check time shall be defined by parameters stabilization time, but not less than 30 minutes. | From MCR CK:  Pumps – once a month. Valves – once in 3 months  From ECR CK:  Pumps - once in 6 months Valves - once in 6 months | | 1. Pump unit parameters at operation by recirculation line – in compliance with TR for the unit.  2. Valves is controlled from MCR, ECR CK without comments. | | |
| 9.2 | Serviceability check of the system pump units TH15,25,35,45D001 | | RP is at power | Once in 672 hours for each of four channels with simultaneous EPSS trial | | Serviceability of the pump units at functioning for recirculation line is confirmed  Serviceability of the pump control and signaling circuits is confirmed  Vibration speed value shall not exceed:  on the pump bearing bodies - 7.1 mm/sec,  on the motor bearing bodies - 4.5 mm/sec,  in frequency range - (10÷1000) Hz | | |
| 10 | Emergency feed water system RS | | | | | | | |
| 10.1 | Check of pumps and valves from CK at MCR, ECR. | RP is at power.  Check time shall be defined by parameters stabilization time, but not less than 30 minutes. | | From MCR CK:  Pumps – once a month. Valves – once in 3 months  From ECR CK:  Pumps - once in 6 months Valves - once in 6 months | | 1. Pump unit parameters at operation by recirculation line – in compliance with TR for the unit.  2. Valves is controlled from MCR, ECR CK without comments. | | |
| 10.2 | Serviceability check of the pump units RS12,22,32,42D001 by trial line | RP is at power | | Once in 672 hours for each of four channels with simultaneous EPSS trial | | Serviceability of the pump units RS12,22,32,42D001 at functioning for recirculation line is confirmed.  Serviceability of the pump control and signaling circuits is confirmed  Vibration speed value shall not exceed:  on the pump bearing bodies - 7.1 mm/sec,  on the motor bearing bodies - 4.5 mm/sec,  in frequency range - (101000) Hz | | |
| 11 | VE – service water supply system for TF and VJ intermediate circuits cooling | | | | | | | |
| 11.1 | Check of pumps and valves from CK at MCR, ECR. | | RP is at power.  Check time shall be defined by parameters stabilization time, but not less than 30 minutes. | From MCR CK:  Pumps – once a month. Valves – once in 3 months  From ECR CK:  Pumps - once in 6 months Valves - once in 6 months | | 1. Pump unit parameters at operation by recirculation line – in compliance with TR for the unit.  2. Valves is controlled from MCR, ECR CK without comments. | | |
| 11.2 | Serviceability check of the pump units VE11,21,31,41D001 | | RP condition is not stipulated | Once in 672 hours for each of four channels with simultaneous EPSS trial | | Serviceability of the pump units is confirmed | | |
| 12 | Reactor building intermediate circuit cooling water system TF | | | | | | | |
| 12.1 | Check of pumps and valves from CK at MCR, ECR. | RP is at power.  Check time shall be defined by parameters stabilization time, but not less than 30 minutes. | | From MCR CK:  Pumps – once a month. Valves – once in 3 months  From ECR CK:  Pumps - once in 6 months Valves - once in 6 months | | | 1. Pump unit parameters at operation by recirculation line – in compliance with TR for the unit.  2. Valves is controlled from MCR, ECR CK without comments. | |
| 12.2 | Serviceability check of the system pump units | RP is at power | | Once in 672 hours for each of four channels with simultaneous EPSS trial | | | Serviceability of the pump control and signaling circuits is confirmed  Vibration speed value shall not exceed:  on the pump bearing bodies - 7.1 mm/sec,  on the motor bearing bodies - 4.5 mm/sec,  in frequency range - (101000) Hz | |
| 13 | Emergency power supply system for the second reliability group consumers | | | | | | | |
| 13.1 | Complex testing of DG with actuation of the process mechanisms by house-load de-energizing factor | | RP is at power in the normal operation mode | Once in 672 hours for each of four channels | | | 1. Voltage recovery time at the sections is not more than 15 sec after DG activating signal generation.  2. DG serviceability check  3. At load connection, the voltage decreasing is not less than 0,8 from the nominal one.  4. The mechanisms activation by steps is as per the sequential startup algorithm.  5. Serviceability check of the activated process mechanisms | |
| 14 | Emergency power supply system for the first reliability group consumers | | | | | | | |
| 14.1 | Storage batteries. Inspection. Perform of equalizing charges | | RP is at power.  SB is in floating mode by the regular mode | The inspection shall be performed once in 672 hours. Performing of equalizing charges as per the manufacturer operating instruction | | | Electrolyte density, voltage at each element are normative.  Voltage at CDB is 230 V | |
| 14.2 | Confirmation of UPS and its components serviceability | | RP is at power | Once in three months | | | Check of SB-supplied UPS serviceability (short-term UPS tripping form feeding mains 0,4 kV).  Monitor d.c. voltage of the intermediate circuit, output UPS voltage, absence of UPS failures at DG complex testing with actuation of the process mechanisms on house-load de-energizing | |
| 15 | Safety-related consumers closed circuit system VJ | | | | | | | |
| 15.1 | Check of pumps and valves from CK at MCR, ECR. | | RP is at power.  Check time shall be defined by parameters stabilization time, but not less than 30 minutes. | From MCR CK:  Pumps – once a month. Valves – once in 3 months  From ECR CK:  Pumps - once in 6 months Valves - once in 6 months | | | 1. Pump unit parameters at operation by recirculation line – in compliance with TR for the unit.  2. Valves is controlled from MCR, ECR CK without comments. | |
| 15.2 | Serviceability check of the pump units VJ11,21,31,41D001 | | RP is at power | Once in 672 hours for each of four channels | | | Serviceability of the pump control and signaling circuits is confirmed | |
| 16 | Emergency fire protection system (UJ) | | | | | | | |
| 16.1 | Check of pumps UJ01,02,03,0405,07D001 valves | | RP is in "cold" condition | Once in 672 hours for each of the pumps | | | 1. The pump unit parameters during operation are in compliance with the TU for the unit.  2. The valves are controlled from MCR without comments | |
| 17 | SS premises ventilation systems | | | | | | | |
| 17.1 | Check of the standby facilities | | RP is at power | Once in 672 hours for each of four channels with simultaneous EPSS trial | | | Serviceability of the ventilation units is confirmed | |
| 18 | EP executive part | | | | | | | |
| 18.1 | Check of the contactor actuation | | RP is at power | Once in 672 hours for each of two sets | | | The condition is in compliance with the design requirements | |
| 19 | In-core instrumentation system (ICIS) | | | | | | | |
| 19.1 | Complex testing of ICIS functioning including ICDS serviceability check | | RP is at 50 % power | At reaching the nominal power | | | The condition is in compliance with the design requirements | |
| 19.2 | Serviceability check of ICIS and ICDS measurement channels | | RP is at power | As per the schedule, but not less than once a month | | | The condition is in compliance with the design requirements | |
| 19.3 | Check of thermal power calculation correction at steady power level 100 % Nnom | | RP is at power 100 % Nnom | At reaching nominal power | | | Condition corresponds to the design requirements | |
| 20 | Hydrogen burning system TS10 | | | | | | | |
| 20.1 | Check of the hydrogen burning system standby channel | | RP is at power | «Schedule of change over to the standby equipment and check of the automatic to reserve source» | | | The equipment is functioning without comments | |
| 21 | Gas treatment system TS20 | | | | | | | |
| 21.1 | Check of SGT standby channels | | RP is at power | «Schedule of transferring to the standby equipment and check of the automatic to reserve source» | | | The parameters are in compliance with OI | |
| 22 | TH system, spent fuel pool chilling group TH18,28,38,48 | | | | | | | |
| 22.1 | Transfer to the standby unit | | RP is at power | «Schedule of transferring to the standby equipment and check of the automatic to reserve source» | | | 1. Parameters of the pump unit during operation are in compliance with TU for the pump.  2. The valves are controlled without comments | |
| 23 | The generator sealing oil system SU | | | | | | | |
| 23.1 | Transfer to the standby unit | | RP is at power | «Schedule of transferring to the standby equipment and check of the automatic to reserve source» | | | Parameters of the pump unit at operation for the closed gate valve and for the system are in compliance with TU for the pump unit | |
| 24 | TG lubrication system SC | | | | | | | |
| 24.1 | Transfer to the standby unit | | RP is at power | «Schedule of transferring to the standby equipment and check of the automatic to reserve source» | | | Parameters of the pump unit at operation for the closed gate valve and for the system are in compliance with TU for the pump unit | |
| Note. trial shall be performed in accordance with the Schedule of trial of safety system that is to be developed by relative BNPP department and approved by BNPP Chief Engineer. | | | | | | | | |

Table 10.2.3 – List of tests and checks of the systems and equipment important to safety to be performed in the process of the Unit shutdown, its transfer to "cold" condition and in "cold" condition

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| No. | Test type | Conditions of testing | Periodicity of checks, terms of tests | Test successful completion criteria |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 1 | Emergency core cooling system (ECCS passive part) YT11,12,13,14B001 | | | |
| 1.1 | Check for tightness of the check valves, gate valves Dnom 300 and SV of the accumulators | ECCS accumulators are filled up to  5,4-6,0 m level, nitrogen pressure in the ECCS accumulators is 1,76-2,35 MPa (17,95-23,97 kgf/cm2). To check the valves tightness, the primary circuit pressure shall be not less than 9,8 MPa (100 kgf/cm2), primary circuit water temperature shall be not less than the hydraulic test temperature | Once in four years or after emergency modes | The pressure beyond the check valve is not varying within 30 min. at pressure differential on its gate as 9,8 MPa (100 kgf/cm2). Presure before SGV is not varying within 30 min at pressure differential on its gate as 9,8 MPa (100 kgf/cm2). The leakages via the gate are not more than the value defined in TR. After assembling, the tightness in the accumulator SV gates corresponds to the requirements of the operating instructions for SV |

| Table 10.2.3, continued | | | | |
| --- | --- | --- | --- | --- |
| No. | Test type | Conditions of testing | Periodicity of checks, terms of tests | Test successful completion criteria |
| 1.2 | Check of ECCS line hydraulic resistance coefficient to the design value. Check of correct selection of the setpoint value for SGV closing by the accumulator level. Check of ECCS accumulator cutoff from the reactor at their emptying. Check of SGV opening and closing time | The reactor top head is removed, RI are extracted, the core is unloaded to fuel pool, the reactor is filled up to the main joint level. ECCS accumulators are filed up to 5,4-6,0 m level, nitrogen pressure in the ECCS accumulators is 1,76-2,35 MPa (17,95-23,97 kgf/cm2) | See Note 1 | Value of the hydraulic resistance coefficient modified to Dnom 300 for the path «ECCS accumulators - reactor» is 8±2,5 (6±1,9 modified to Dnom 279). After SGV closing, water level in the accumulators is provided as 0,8±0,2m. Time of SGV full closing (opening) is not more than 10 sec |
|  | Note  1. If any factors are revealed during operation, which can cause deviation form the design ECCS line hydraulic resistance coefficient value, the tests shall be performed, similar to those during commissioning. Tests of ECCS passive part shall be performed to check serviceability of channels as a whole and define the hydraulic resistance coefficient for the accumulator-reactor line with boric acid solution flushing to the unsealed reactor at pressure in the accumulators as 1,76 - 2,35 MPa (17,95 – 23,97 kgf/cm2):  - after replacement of the check valves Dnom 300;  - after replacement of the shutoff gate valves Dnom 300;  - after performing the repair activities at check valves Dnom 300 and shutoff gate valves Dnom 300 related to replacement of the valves elements and causing changes in the continuous-flow part or pipelines Dnom 300;  - pressure differential increasing over the permissible value required for opening the check valve. | | | |
| 2 | Reactor YC10B001 | | | |
| 2.1 | Horizontality check of the vessel sealing surface | Check of the vessel sealing surface horizontality shall be performed at the unsealed reactor | The check shall be performed prior to refueling, after PTU dismantling | Value of the sealing surface incline shall not be more than 0,0005 relative unit |
| 2.2 | FA check for FE cladding integrity | FE cladding integrity shall be controlled during operation and after the reactor shutdown | FCIM periodicity during the reactor operation and after its shutdown shall be as per the instruction on FCIM | Value of permissible coolant activity increasing during the reactor operation, and water increasing in FCIM rack during testing is as per the instruction on FCIM |
| 2.3 | Check of CPS AR-coupled drive characteristics | Conditions for checks are in compliance with the operating instruction for the drive | Periodicity of checks is in compliance with the operating instruction for the drive | Test successful completion criteria checks are in compliance with the operating instruction for the drive |
| 2.4 | Check of RMJ sealing channel sizes | The check shall be performed at the unsealed reactor at extracted PTU and studs M170. The coolant shall be drained to 200 - 300 mm below RMJ surface | The check shall be performed at each RMJ unsealing | Difference between projection of the check ball with 5,0 mm diameter over RMJ surface and indent (depressed) size on the UU sealing surface shall not be les than 1,3 mm |
| 2.5 | Measuring of hold-on tube residual elasticity | The check shall be performed after the reactor unsealing and UU dismantling. The coolant level shall be to 200 - 300 mm below RMJ surface | At each scheduled reactor unsealing | The size of residual elastic deformation of the hold-on tubes shall be not less than 0,4 mm |
| 2.6 | Check for tightness of CPS drive housing joint with the reactor top head nozzle | The joint tightness check shall be performed at the upper unit mounted to the upper unit inspection cavity | After each joint sealing | Pressure by the reference manometer is constant. No leakages and wetting |
| 3 | Second stage hydraulic accumulators system (ECCS passive part) TH16,17,26,27,36,37,46,47B001 | | | |
| 3.1 | Check for tightness of the check valves, gate valves Dnom 300 and accumulator SV | ECCS accumulators are filled up to the nominal level, nitrogen pressure in the ECCS accumulators is 1,76-2,35 MPa (17,95-23,97 kgf/cm2). To check the valves tightness, the primary circuit pressure shall be not less than 9,8 MPa (100 kgf/cm2), primary circuit water temperature shall be not less than the hydraulic test temperature | Once in four years or after emergency modes | The pressure beyond the check valve is not varying within 30 min. at pressure differential on its gate as 9,8 MPa (100 kgf/cm2). Presure before SGV is not varying within 30 min at pressure differential on its gate as 9,8 MPa (100 kgf/cm2). The leakages via the gate are not more than defined by technical requirements for the valves. After assembling, the tightness in the accumulator SV gates corresponds to the requirements of the operating instructions for SV |
| 4 | TH system, emergency and scheduled cool-down group TH10,20,30,40 | | | |
| 4.1 | Check of the system check valves tightness | RP condition during SPM;  - at refueling | Twice a year | Within monitoring period  (30 minutes), pressure in the pipeline section upstream of the check valves did not exceed 0,5 MPa (5,1 kgf/cm2) |
| 5 | TH system, emergency boron injection group TH15,25,35,45 | | | |
| 5.1 | Check of the system check valves tightness | RP condition during SPM;  - at refueling | During the Unit shutdown SPM | Tightness of the system check valve is confirmed |
| 6 | VE – service water supply system for TF and VJ intermediate circuits cooling | | | |
| 6.1 | Serviceability check of the electric-driven system valves | RP condition during SPM;  - at refueling | Once in 672 hours for each of four channels | Design functioning of valves is confirmed |
| 6.2 | Serviceability check of the pump units VE11,21,31,41D001 | RP condition is not stipulated | Once in 672 hours for each of four channels with simultaneous EPSS trial | Serviceability of the pump units is confirmed |
| 7 | Reactor building intermediate circuit cooling water system TF | | | |
| 7.1 | Serviceability check of the electric-driven valves | RP condition is "Cold" | Once in 672 hours simultaneously with the relevant safety systems | Design functioning of the electric-driven valves is confirmed |
| 7.2 | Serviceability check of the system pump units | RP condition is "Cold" | Once in 672 hours for each of four channels with simultaneous EPSS trial | Serviceability of the pump units TF10(20,30,30,40)D001, TF21(31)D001 is confirmed  Serviceability of the pump control and signaling circuits is confirmed  Vibration speed value shall not exceed:  on the pump bearing bodies - 7.1 mm/sec,  on the motor bearing bodies - 4.5 mm/sec,  in frequency range - (101000) Hz |
| 8 | Emergency hydrogen removal system XP | | | |
| 8.1 | Check of serviceability and readiness of the system equipment to perform the defined functions | The Unit is shutdown for preventive maintenance | Once a year during SPM | Serviceability of tested hydrogen recombiner is confirmed |
| 9 | Main steam-line system RA | | | |
| 9.1 | Check of SG PPD serviceability | Transient condition:  Cool-down up to cold condition, at the unit shutdown for the core refueling | In the period of the Unit shutdown with refueling | SG PPD readiness for operation by direct purpose is confirmed;  Serviceability of SG PPD position signaling and control circuits is confirmed |
| 9.2 | Check of MSIV RA10,20,30,40S004 serviceability | «hot» condition | In the period of the Unit shutdown with refueling | MSIV readiness for operation by direct purpose is confirmed;  Serviceability of MSIV position signaling and control circuits is confirmed;  Design requirement to MSIV closing time is confirmed |
| 9.3 | Check of BRU-A  БРУ-А RA10÷40S003 serviceability | Transient condition:  Cool-down up to cold condition, at the unit shutdown for the core refueling | In the period of the Unit shutdown with refueling | BRU-A readiness for operation by direct purpose is confirmed;  Serviceability of BRU-A position signaling and control circuits is confirmed;  Design requirement to BRU-A opening (closing) time is confirmed |
| 10 | CPS CR | | | |
| 10.1 | Check of CPS CR drop time. | RP is in hot condition (4 RCPS are in operation) | Prior to beginning and upon expiration of the fuel lifetime | CPS CR drop time is within (1,2Q4) sec. |

Requirements to surveillance for the radiation monitoring devices

Table 10.2.4

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Measuring channel description | Periodicity of tests | | | Operation mode for testing |
| for serviceability | channel calibration | functional tests |
| 1. ECCS water activity measurement channels | Once a day | Once a year | Once a month | At all modes |
| 2. BRU-A pipelines gas-vapor mixture activity measurement channels | Once a day | Once a year | Once a month | At power operation |
| 3. Primary circuit coolant activity measurement channels | Once a day | Once a year | Once a month | At all modes |
| 4. Containment radiation situation measurement channels | Once a day | Once a year | Once a month | At all modes at fuel availability in FP |
| 5. Annulus measurement channels | Once a day | Once a year | Once a month | At power operation |
| 6. ZN33 system cooling water activity measurement channels | Once a day | Once a year | Once a month | At all modes |
| 7. Measurement channels of air-steam mixture activity at turbine condensate air removal system exhaust | Once a day | Once a year | Once a month | At power operation |
| 8. Measurement channels of fresh steam activity in SF steam-lines | Once a day | Once a year | Once a month | At power operation |
| 9. Gas-aerosol exhausts to the stack control equipment | Once a day | Once a year | Once a month | At all modes |
| 10. Wastewater activity measurement channels | Once a day | Once a year | Once a month | At all modes |
| 11. Radiation situation monitoring equipment in ZX, ZE buildings | Once a day | Once a year | Once a month | At all modes |
| 12. Closed circuit TF water activity measurement channels | Once a day | Once a year | Once a month | At all modes |
| 13. Steam-generators RZ blow-down activity measurement channels | Once a day | Once a year | Once a month | At all modes |

**10.3 The Unit safety operation conditions at the equipment testing and checks**

10.3.1 At the safety-related systems equipment testing and checks, including protections and interlocks maintenance, it is required to observe The Unit safety operation conditions described in sections 4, 5, 6, 7 of this specification for different RP conditions. Besides, it is required to perform additional requirements specified below.

10.3.2 Commissioned protections and interlocks shall be in operation within all operation time of the equipment at which they are mounted.

Withdrawal of protections and interlocks is allowed in individual cases for check and maintenance in compliance with Appendix К item 2.2, 2.3.

10.3.3 At the Unit power operation, it is not allowed to withdraw from operation simultaneously two sets of EP or protections and interlocks of more than one SS channel.

To perform tests and checks, maintenance of protections and interlocks, it is not allowed to withdraw from operation more than one SS channel. At interlocks check, it is allowed to assemble SS circuits mechanisms to testing position for the period not more than eight hours. In case of time exceeding, further check shall be performed with setting the circuits to operating position.

At primary and secondary circuits unsealed for maintenance, SS channel does not include:

1) breaking protections of the primary circuit: ΔTs< 10 °С and Pct> 0,3 kgf/cm2;

2) breaking protections of the secondary circuit: ΔTs > 75 °С and Psc< 50 kgf/cm2;

3) steam-generator emergency power supply system;

4) isolating valves at condition of fixation in open position of the valves providing heat removal from the fuel pool;

5) ECCS HA;

6) SG PPD, PRZ PSD, BRU-A.

10.3.4 At failure revealing in any element of the checked SS channel, it is allowed to withdraw this channel to maintenance in compliance with the requirements specified in item 5.1.7.

10.3.5 Confinement system tests.

Requirements to the equipment and systems condition at the confinement system testing are the same as for the “cold condition” of the Unit (item 4.1.1), taking into account the following special conditions of testing:

1) for the time of the Unit confinement system testing, its tightness shall be provided by closing valves of isolating process systems groups by simulating the signal “overpressure in confinement Рexc.= 0,3 kgf/cm2”.

2) It is allowed to terminate FP cool-down at detecting leakages at the confinement system testing for the time not more than three hours.

3) It is allowed to terminate forced circulation via the reactor core at detecting leakages at the confinement system testing for the time not more than three hours. Permissible forced circulation time may be detailed taking into account operation conditions of the specific fuel loading.

10.3.6 Hydraulic tests of the primary and secondary circuits.

Equipment condition at hydraulic tests of the primary and secondary circuits shall meet the requirements stated in item 4.1.1.1.

Minimal temperature of RP primary circuit equipment walls at hydraulic test is specified in Appendix В. Hydraulic testing parameters are specified in Table 10.3.1.

The following requirements shall be fulfilled additionally:

1) it is not allowed to increase pressure in primary circuit over 35 kgf/cm2 (3,4 MPa), and in the second circuit over 15 kgf/cm2 (1,47 MPa) at equipment surface temperature below that of specified in Appendix В;

2) at SG hydraulic tests by the secondary circuit, primary circuit pressure shall be higher than secondary circuit pressure to not less than 10 kgf/cm2 (1,0 Mpa) to avoid “pure” condensate leakages from secondary circuit SG to the primary circuit;

3) during relief tank body hydraulic tests, primary circuit pressure shall be not less than 15 kgf/cm2 (1,47 MPa).

10.3.7 PRZ PSD testing by actual pressure increasing.

Requirements to equipment and systems condition at PRZ PSD testing are the same as in item 4.1.2, taking into account the following special conditions for testing:

1) it is allowed to disable PRZ PSD PPV YP21(22,23)S002,003 for PRZ PSD serviceability check by real pressure increasing, but not more than for four hours;

2) it is allowed to trip RCPS, terminate forced circulation via the reactor core for the time of PRZ PSD serviceability check by real pressure increasing, but not more than for four hours.

10.3.8 Periodical check of CPS AR passability by way of by-turn drop in the mode of the drive de-energizing.

10.3.9 ECCS hydraulic tank check.

1) At leakages via the checked valves do not allowing to provide the channel parameters compliance to the design, it is required to close both FSGV at the line and changeover the Unit to “cold” condition.

2) At preparing boron solutions for ECCS passive part, boric acid shall be used with contents of isotope BORON-10 not less than 19,5 % of all isotopes sum.

3) In the process of RP operation, simultaneous opening of valves at two bypass lines of ECCS passive part check valves is not allowed.

10.3.10 Check of CPS serviceability shall be performed in compliance with the working programme on the reactor control and protection system complex check prior to reaching minimally controlled level with effect to CPS CR drive control circuit.

At complex check, it is not allowed to lift to the upper level limit switch more than one CPS CR group, at the same time, the other CPS CR group can be in intermediate position, and all other CPS CR groups shall be in the utmost bottom position.

10.3.11 Check of the core neutron-physics characteristics shall be performed as per the working programme.

At the programme fulfillment, the following safety operation conditions shall be observed:

1) Neutron power level is not higher than 10-7 % of the nominal one, power fluctuation period is not less than 999 sec.

2) Ambient temperature of NFMTC connectors at operation shall not exceed 105 °С. Short-time temperature exceeding is allowed up to 200 °С within not more than 6 minutes.

3) At RCPS operation, primary circuit pressure shall be not lower than the minimally permissible pressure at RCPS suction.

4) Maintain PRZ level corresponding the reactor zero power.

5)Steam blanket without nitrogen admixtures shall be createdin the pressurizer prior the reactor bringing to MCL, PRZ level is not less than 5100±150 mm, pressure - 15,7 MPa (160 kgf/cm2).

6) Each of ECCS hydraulic tanks is filled with boric acid solution at concentration not less than 16 g/kg up to level (6500±100) mm, pressure – 6±0,10,3 MPa   
(60±13 kgf/cm2). Temperature in the hydraulic tanks shall be within the range of 65-75оС.

7 ) At the Unit changeover to the minimally-controlled level of power, safety limit conditions specified ins section 4.1.3 of the technical specification shall be fulfilled.

8) Primary circuit water temperature fluctuation shall not exceed the limits of the range (260÷280) °С.

Parameters of hydraulic tests

Table 10.3.1

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| System  (system part, equipment, pipelines) description | Operating pressure kgf/cm2 (MPa) | Hydraulic test pressure, permissible limits of fluctuations, kgf/cm2 (MPa) | Inspection pressure kgf/cm2 (MPa) | Permissible rates of pressure increasing, decreasing, kgf/cm2/min (MPa/min) | Hydraulic tests temperature, °С | | Permissible rates of temperature change, °С/hr | |
| min. | max.  (therm) | heat-up | cool-down |
| 1. Primary circuit | 180 (17,6) | 250255  (24,525,0) | 200 (19,6) | 10 (1,0) | see Appendix В | 130 | 20 | 30 |
| 2. Relief tank body with discharge pipeline section up to PRZ PSD | see note | 1011 (0,981,0) | 8,0 (0,8) | 10 (1,0) | 20 | 60 | 20 | 30 |
| 3. Relief tank heat-exchanger | 6 (0,59) | 810 (0,81,0) | 6,0 (0,6) | 10 (1,0) | 20 | 60 | 20 | 30 |
| 4. ECCS HA with ECCS pipelines sections up to valves YT11,12,13,14S001 | 60 (5,9) | 84,7±4,1 (8,3±0,4) | 68 (6,7) | 10 (1,0) | 20 | 40 | 20 | 30 |
| 5. Second stage ECCS HA | 25 (2,45) | 35,31±2,04  (3,46±0,2) | 28,48 (2,8) | 10 (1,0) | 20 | 40 | 20 | 30 |
| 6. Second stage steam-generator test for strength | 80 (7,8) | 110115  (10,811,3) | 88 (8,6) | 10 (1,0) | 70 | 130 | 20 | 30 |

**10.4 The main rules and methods of performing the process operations at the equipment testing and serviceability check**

#### 10.4.1 At primary circuit hydraulic tests:

1) all low pressure pipelines of RP auxiliary systems are reliably disconnected from high pressure pipelines by the interfacing valves of these systems.

The electric drives of the valves in this position are de-energized with except for the primary circuit emergency gas removal system and air removal from RCPS circuits;

2) there is nitrogen blanket or steam cushion in PRZ, PRZ level is 11100 mm (level calculation from the bottom internal generatrix of PRZ shell), PRZ PSD are ready for operation, RT level is nominal;

3) two RCPS are in operation, the others are ready for operation, the intermediate circuit cooling water and sealing water is supplied to them.

It is allowed to trip RCPS, terminate forced circulation through the reactor core for the time of the primary circuit hydraulic testing, but not more than for four hours;

4) each SG level is (3700Q3800) mm, SG PPD are ready for operation;

5) at primary circuit pressure more than 70 kgf/cm2 , first and second stage ECCS HA are connected to the primary circuit, ECCS media parameters are nominal;

6) at the primary circuit coolant temperature more than 60 °С, the intermediate circuit cooling water supply to the heat-exchanger of the secondary circuit RCPS is mandatory;

7) at SG hydraulic tests, the temperature difference in different points of SG vessel shall not exceed 40 °С, and temperature shall not exceed the limits specified in item 3.2.2.2;

8) at the primary circuit hydraulic tests, temperature difference between PRZ top-bottom shall not exceed 50 °С, and temperature shall not exceed the limits specified in item 3.2.2.2;

9) temperature of medium supplied at hydraulic tests of the primary circuit and secondary circuit SG is not less than 80 °С;

10) ambient temperature at hydraulic tests shall not be less than 20 °С.

For the period of primary and secondary circuit hydraulic tests, prior to primary circuit pressure increasing over 19,6 MPa (200 kgf/cm2) and over 8,6 MPa (88 kgf/cm2) in the secondary circuit, all I&C sensors not designed for hydraulic test pressure shall be disconnected, and the measures shall be taken preventing their failure due to leaking of the tripping valves. At the same time, by taking the organizational measures, a possibility to monitor the primary and secondary circuit hydraulic test pressure at MCR shall be provided.

During the primary circuit hydraulic tests at the reactor fuel loaded, it is required to observe the following restrictions for fuel:

a) it is allowed to maintain pressure 24,5 MPa (250 kgf/cm2) not less than 10 minutes single-time (totally not more than 60 minutes within all FA operation period);

#### 10.4.2 RCPS allows hydraulic testing within primary circuit by pressure 24,5 MPa (250 kgf/cm2) at the coolant temperature corresponding to the established requirements, at the same time it is allowed not to feed sealing water provided that the intermediate circuit cooling water is supplied. In this case the vents on sealing water supply and removal shall be closed.

RCPS allows pressurizing by outer air pressure 0,46 MPa abs. (4,7 kgf/cm2 abs.).

#### 10.4.3 Prior to pressure increasing in the relief tank in order to perform hydraulic testing, pressure shall be created in the primary circuit not les than 1,47 MPa (15 kgf/cm2) to avoid ingress of “pure” condensate from RT via PRZ PSD to the primary circuit.

#### 10.4.4 If BRU-A is withdrawn for repair at the Unit operation at power, and its serviceability is not possible to check without actuating the valve and its opening, serviceability check shall be performed in the following sequence:

1) the Unit operates at power not more than 75 % Nnom;

2) APC operates in the neutron power maintaining mode (mode “N”);

3) EPCS operates in secondary circuit pressure maintaining mode (RD-1 mode).

#### With observation of the specified requirements, partial opening of BRU-A valve shall be performed by key at MCR. The degree of BRU-A opening is not more than 15 %.

#### After stabilizing the primary and secondary circuit parameters, BRU-A valve shall be transferred to automatic control mode, after that it shall automatically close.

#### 10.4.5 Trial of first stage ECCS passive part:

1) prior to testing ECCS accumulators, check the following conditions:

a) ECCS HA SV are serviceable ad checked for their activation pressure;

b) I&C providing for control and measuring of ECCS passive part parameters are serviceable;

c) ECCS HA parameters are nominal;

d) PRZ supply system is in readiness condition;

2) after checking the initial condition, it is required to disconnect the emergency cool-down system from the primary circuit and take measures on disconnection of low pressure pipelines of this system;

3) create nitrogen blanket in PRZ at the following parameters:

a) pressure - 1,96 MPa (20 kgf/cm2);

b) level - 11600 mm;

c) primary circuit temperature - (90÷130) °С.

4) increase primary circuit pressure up to 6,4 MPa (65 kgf/cm2), open fast-acting shutoff gate valves connecting ECCS accumulator to the reactor and make sure that pressure and level in the tank have not been changed;

5) set the interlock setpoints for closing the shutoff gate valves Dnom 300 at the level value to 500 mm less than actual level in ECCS accumulator;

6) trip the blow-down regulator, trip PRZ level control device, open all valves at the primary circuit coolant discharge lines. Monitor activation of the check valves Dnom 300 upon reaching ΔРopn not more than 0,029 MPa (0,3 kgf/cm2);

7) at primary circuit pressure decreasing to 3,9 MPa (40 kgf/cm2), close valves at the primary circuit coolant discharge lines and activate the blow-down regulator for maintaining this pressure;

8) make sure, that both shutoff gate valves Dnom 300 are closed by interlock, and level and pressure in ECCS tank have been stabilized.

#### Create nominal parameters in the accumulator and set the design interlock setpoints for closing the shutoff gate valves Dnom 300.

#### After completing the operations on ECCS checking, make sure in serviceability of vents on check valves bypass by way of single-time cycle “opened-closed”.

#### Simultaneous check of two and more ECCS passive part fast-acting gate valves is forbidden.

#### 10.4.6 In case of impermissibility of full valves opening due to process conditions at by-turns check of valves remote control channels at the functioning equipment, it is recommended to check serviceability of valves by giving short-term command from MCR (ECR) for moving the valve till its getting off the end switch or sealing area and returning back to the initial condition.

#### Prior to perform the operations, serviceability of signalization shall be checked at ECR, as well as availability of power supply and I&C serviceability including MCR NFME.

#### The possibility to control the Unit equipment from ECR shall be checked by way of trial activation (tripping) of the Unit equipment from ECR after this equipment have been tried from MCR as per the approved trial run schedules. All failure shall be eliminated immediately upon their revealing.

#### It is forbidden to perform operations from ECR at the unstable mode of the Unit.

#### 10.4.7 At primary circuit SG draining, to prevent forming of hydrogen-and-nitrogen mixture under the primary circuit SG header covers, supply nitrogen to the drained primary circuit SG space via air vents of the regular nitrogen line.

#### The vents on the gaseous mixture removal line from SG drained by the primary circuit shall be closed.

#### After draining SG by the primary circuit and primary circuit loops, prior to open the primary circuit header covers , perform also nitrogen blow-down of the hearses within 15 minutes from the regular line via primary circuit SG air vents to the reactor side to remove gaseous mixture containing hydrogen and accumulated in inner primary circuit primary circuit SG caves.

#### The vents on the gaseous mixture removal line from primary circuit SG shall be closed at the SG being blown-down by nitrogen.

#### Prior to inspection and periodically, during inspection of the inner SG caves, it is required to blow them down by compressed air supplied by hose via SG hatches to primary circuit headers after removal the regular or process covers.

#### 10.4.8 Check of 1st and 2nd stage ECCS HA check valves tightness.

#### For the first check valve (from the reactor), the bypass valves shall be opened at the second check valve, prior to checking. For the second check valve (at the reactor side) the bypass valves shall be opened at the first check valve, prior to checking.

#### If the test for tightness criteria is not satisfied, the valves shall be subjected to inspection during the next SPM. At leakages via the check valves preventing provision of ECCS channel serviceability, it is required to transfer the Unit to “cold” condition.

#### 10.4.9 The main methods of safety operation at checking the core neutron-physical characteristics.

#### 1) In water-exchange process, to reduce boric acid concentration in the primary circuit coolant, upon reaching the starting interval, water- exchange shall be terminated for the time sufficient to equalize boric acid concentration in the primary circuit, PRZ, make-up deaerator, in controlled leakages tank (concentrations difference is not more than 1 g/kg).

#### Sampling for boric acid concentration control shall be performed at least once in 30 minutes in addition to the continuous monitoring.

#### 2) Pure condensate flow-rate in the starting interval of boric acid concentration in the primary circuit coolant is not more than 6,5 t/hr over the required to compensate xenon poisoning at startups from poisoned condition.

#### Procedure of defining compensatory flow-rate of pure condensate shall be agreed upon as per the established sequence and approved by chief engineer.

#### At unavailability of the approved procedure, permissible flow-rate of pure condensate in starting interval is not more than 6,5 t/hr.

#### 3) Stabilize the reactor power at level 10-5÷10-3 % Nnom effecting CPS CR of the operating group.

#### At the reactor period less than 100 sec and further period decreasing by NFME readings, terminate open primary circuit water-exchange. Monitor critical (feebly supercritical) reactor condition by the period close to infinity. At period reducing up to 90 sec, bring the reactor to feebly sub-critical condition by moving CPS CR of operating group by 3…5 cm pitches.

#### After reactor bringing to MCL of power, after completing boron removal from primary circuit and boric acid concentration equalizing in the reactor, PRZ and make-up deaerator, record the following parameters, at which MCL of power has been reached, in the operative log-book:

#### - boric acid concentration in primary circuit coolant;

#### - position of 10th CPS CR group;

#### - primary circuit pressure and temperature;

**-** number of effective days operated by the reactor after refueling up to startup moment.

# REFERENCES

1 The main rules for the nuclear power plant operation assurance (ОПЭ АС),   
third edition, РД ЭО 0348-02

2 General provisions for the nuclear power plant assurance (OПБ-88),   
ПНАЭ Г-1-011-89

3 Reactor power plants equipment and pipelines installation and safe operation code, ПНАЭ Г -7-008-89

4 Standard technical specification for operation of NPP Units with the reactor type ВВЭР-1000, TРВ-1000-4, 1997

5 Sanitary code for the personnel admission to the containment vessel at operation of the Units with ВВЭР 1000, СТГО-AС-92

6 Nuclear safety rules of reactor plants (ПБЯ РУ АС-89). Amendment No.1 dd. 01.09.2000, ПНАЭ Г-1-024-90

7 Nuclear safety rules of nuclear power plants. Section 4. (Amendment No.1  
dd. 01.09.2000), ПБЯ-04-74

8 Nuclear safety rules during spent nuclear fuel transportation, ПБЯ-06-08-77

9 Rules of designing and operation of emergency cooling and heat removal from the nuclear reactor to the end absorber, ПНАЭ Г-5-020-90

10 Rules for design and operation of localizing safety systems of nuclear power plants, ПНАЭ Г-10-021-90

11 Requirements to control systems important to nuclear power plant safety, НП-026-01

12 General provisions for design and safe operation of emergency power supply systems of nuclear power plants, ПНАЭ Г-9-026-90

13 Safety rules when storing and transporting nuclear fuel at nuclear power objects, ПНАЭ Г -14-029-91

14 Rules of radiation safety under operation of nuclear power plants, ПРБ-AС-99

15 Radiation safety norms, НРБ-96

16 Main sanitary norms of handling with radioactive substances and other ionizing radiation sources, OСП-72/87

17 Sanitary rules for designing and operation of nuclear power plants,   
(СП АС-03) SanPin 2.6.1.24-03

18 Main sanitary rules for radiation safety, OСП-72/87

19 Fire-fighting rules under operation of nuclear power plants, ППБ AС-95

20 Provision on the procedure of investigation and recording the malfunctions in nuclear power plants operation, ПНАЭ Г-12-005-91

21 Norms of primary circuit water chemistry, 446 Д3

1. Norms of primary circuit water chemistry, 446 Д4
2. Working technical specification of safety operation for Balakovskaya NPP Unit No.4
3. Methods of radiation monitoring over the primary circuit coolant leakage into NPP steam generator water from ВВЭР-1000 (standard visual examination method), РД ЭО 0333-02.
4. Technical decision No. 7717-03/08-160. on BNPP-I reactor plant planned cooling mode with sub-systems TH10,20,40 of primary circuit emergency and planned cooling and fuel pool cooldown.
5. Letter of JSC OKB «Gidropress» No.044/10-02-10388 of 22.07.2014 «Temperature at the outlet from the upper unit».
6. Standard control methods of fuel element cladding tightness. Fuel assemblies of ВВЭР-1000 reactors. РД ЭО 1.1.2.10.0521-2009.

# *aPPENDIX A*

List of EP, PP and APP signals

Table А.1 – List of EP signals

|  |  |  |
| --- | --- | --- |
| Signal description | Justification of signal  necessity | Determinative  modes |
| 1. Period of thermal neutron flux fluctuation within the startup range,  less than10 sec  Period of thermal neutron flux fluctuation within the operating range,  less than10 sec  Thermal neutron flux variation period within the source range 10 sec | The reactor trip at unforeseen decreasing of the thermal neutron flux fluctuation period within the startup range  The reactor trip at unforeseen decreasing of the thermal neutron flux fluctuation period within the operating range | Malfunction in the boron control system. Uncontrolled withdrawal of the absorbing rods. Control rod ejection at CPS drive housing rupture |
| 2. Neutron flux density level in the startup measurement range. The setpoint is variable. To be set by the operator.  Neutron flux density level in the operating range, Ndef, not more. The setpoint is variable. Ndef shall be set discretely in 1% within the range (3÷107) % Nnom by the operator as per the operating instruction or automatically  Neutron flux density level within the source range | The reactor trip at unforeseen thermal neutron flux density level increasing in the startup range  The reactor trip at unforeseen increasing of the reactor power during operation at partial levels of power, and failure/de-energize of equipment/systems which affect the reactor power | Mistakes of the operator at the reactor power ascension. Malfunction in the boron control system  Uncontrolled withdrawal of the absorbing rods. |

*APPENDIX A CONTINUATION*

Table А.1 continuation

|  |  |  |
| --- | --- | --- |
| Signal description | Justification of signal  necessity | Determinative  modes |
| 3. Neutron flux density level in the operating range, 107 % Nnom, not more. The setpoint is constant | The reactor trip at unforeseen increasing of the reactor power during operation in nominal mode, complete set of the functioning equipment | Uncontrolled withdrawal of the absorbing rods.  Malfunction in the boron control system |
| 4. Neutron flux density level in the operating fluctuation range, % Nnom:  - at tripping one of four running RCPS and at power of more than 75% Nnom;  - at tripping of one of the three running RCPS (two opposite RCPS remain in operation) and at power of more than 60% Nnom;  - at tripping of one of the three running RCPS (two adjacent RCPS remain in operation) and at power of more than 50% Nnom;   * at tripping of three or more operating RCPS and at power of more than 5% Nnom | The reactor trip at unforeseen increasing of the reactor power during operation in operating mode at RCPS tripping | RCPS tripping |
| 5. Difference between saturation temperature in the primary circuit and maximal temperature in any hot leg is less than 10 С | The reactor trip at the core flow decreasing | Primary circuit pipeline breaks. Unforeseen PRZ PSD opening. False injection to PRZ from make-up system |

*APPENDIX A CONTINUATION*

Table А.1, continued

|  |  |  |
| --- | --- | --- |
| Signal description | Justification of signal  necessity | Determinative  modes |
| 6. Coincidence of the following signals:   * pressure above the core less than 14,7 MPa (150 kgf/cm2); * the reactor power is more than 75 % Nnom | The reactor trip at disturbance in heat removal from the primary circuit and the reactor core | False injection to PRZ from make-up system and boron injection.  Unforeseen opening of SG PPD or PRZ PSD.  Primary circuit leakage |
| 7. Coincidence of the following signals:   * coolant temperature in the hot legs of loops is more than 260 С; * pressure above the core less than 13,73 MPa (140 kgf/cm2) | The reactor trip at disturbance in heat removal from the primary circuit and the reactor core | Primary circuit leakage.  Unforeseen opening of PRZ PSD |
| 8. Pressure differential drop at running RCPS from 0,392 MPa (4 kgf/cm2) to 0,245 MPa (2,5 kgf/cm2) for the time less than 5 с | The reactor trip at unforeseen sharp decreasing of core coolant flow | RCPS sticking.  RCPS shaft rupture |
| 9. Coincidence of the following signals by any of four steam-lines:   * pressure in the pipeline is less than 4,9 MPa (50 kgf/cm2); * primary and secondary circuit saturation temperature difference (in steam-line) is more than 75 С | The reactor trip at fast pressure drop in the steam-line due to leakage or operational malfunctions | Steam-line breakage.  SG feed water lines breakage.  Unintended opening of steam-relieving units (SG PPD, BRU-A, BRU-K) |
| 10. RCPS de-energizing:   * one of two or two of three running RCPS; * two of four running RCPS at the reactor power more than 75% Nnom with 6 sec time delay | The reactor trip at unforeseen sharp decreasing of core coolant flow | Tripping of different number of RCPS |
| 11. Pressure in any of four SG is more than 7,84 MPa  (80 kgf/cm2) | The reactor trip at unforeseen sharp reducing of SG steam flow | Load shedding by the turbine (including complete) at insufficient capacity of BRU-K relieving units. False MSIV closing |

*APPENDIX A CONTINUATION*

Table А.1, continued

|  |  |  |
| --- | --- | --- |
| Signal description | Result of the protection functioning | Determinative  modes |
| 12. Seismic effect, m/sec2, more than 0,2g | The reactor trip at the earthquake | Seismic effect is higher than the design-basis |
| 13. 380 V voltage loss at 2 CPS insertions | The reactor trip at CPS equipment de-energizing | Loss of reliable power supply of the CPS equipment |
| 14. SG water level is less than (Нnom-650) mm | The reactor trip at unforeseen deterioration of heat removal by the loop as the result of normal feed water flow-rate loss, consequence of which is temperature increasing at the reactor core bottom | Feed water pipeline breaks. Tripping of the turbine feeding pumps |
| 15. Frequency drop at three of four RCPS feeding sections to less than 46 Hz with 1 sec delay | The reactor trip at core flow decreasing | Frequency decreasing in the power plant house-load supply mains |
| 16. Pressure under containment (excessive) – more than 0.030 MPa (0.306 kgf/cm2) | The reactor trip at sharp unforeseen pressure increasing under containment | Large leakages from the primary circuit. Large leakages from secondary circuit steam-lines within the containment |
| 17. Primary circuit pressure is more than 17,5 MPa  (180 kgf/cm2) | The reactor trip at sharp increasing of primary circuit volume and temperature | False MSIV closing. Loss of normal feed water flow-rate. Main steam header break. Unintended BRU-K opening |
| 18. Coolant temperature in any of four hot legs of loops is more than (tnom.+8) С | The reactor trip at unforeseen temperature increasing in the loop | RCPs tripping at faulty ROM device —► RCPs tripping simultaneous with PUR device failure. Two of four RCPs at APP failure —► two of four RCPs simultaneous with APP failure |
| 19. PRZ coolant level is less than 4000 mm | The reactor trip at PRZ level decreasing in the modes related to primary circuit coolant volume variation (decreasing) | Non-compensatory primary circuit leakage |

*APPENDIX A CONTINUATION*

Table А.1, continued

|  |  |  |
| --- | --- | --- |
| Signal description | Result of the protection functioning | Determinative  modes |
| 20. Pressing EP button at MCR or ECR | The reactor trip by the operator from MCR or ECR | Requirements of “Nuclear safety rules of reactor plants" (PBYA RU AS-89), Moscow, 1991 PNAEG-1-024-90 |
| 21. Boiling margin at FE surface with maximal power-flux, *ncrisis*, less than 1,2 | The reactor trip at boiling margin decreasing | RCPS trip at non-operating ROM.  False MSIV closing.  One CR ejection.  Simultaneous trip of two of four RCPS at APP failure.  Loss of normal feed water flow-rate.  MSH breakage.  Unintended BRU-K opening |
| 22. Local power-flux of maximally intensive FE is more than 448 Wt/cm\* (with the time delay of 80 seconds) | The reactor trip at local power-flux increasing | RCPS trip at non-operating ROM.  False MSIV closing.  One CR ejection.  Simultaneous trip of two of four RCPS at APP failure.  Loss of normal feed water flow-rate.  MSH breakage.  Unintended BRU-K opening |
| Notes  \* The setpoint shall be calculated depending on position by the core height and FE type in which maximum is reached;  1. Value of permissible local power-flux is given for four running RCPS;  2. Values of setpoints as for boiling margin at FE surface and local power-flux shall be detailed by results of commissioning.  The setpoints shall be justified based on the results of ICIS mathematical support cross-verification by codes, which have been used at RP design justification. | | |

*APPENDIX A CONTINUATION*

Table А.2 – List of preventive protection PP-1 signals

|  |  |
| --- | --- |
| Signal description | Result of the protection functioning |
| 1. Neutron flux fluctuation period within the ranges:  - source range less than 20 sec  - startup, less than 20 sec;  - operating, less than 20 sec; | Limitation of thermal neutron flux flow period in all ranges. |
| 2. Neutron flux density level within the operating measurement range, the setpoint is variable, it shall be set in ratio 104:107 % of Ndef | The reactor power decreasing at unforeseen increasing of the reactor power during operation at partial levels of power and failure/de-energizing of equipment/systems, affecting unit power |
| 3. Pressure above the core, more than 16,7 MPa (172 kgf/cm2) | The reactor power decreasing at unforeseen primary circuit coolant volume and temperature increasing |
| 4. Coolant temperature in any of four hot legs, more than (Тhot.nom.+3) С | The reactor power decreasing at unforeseen coolant temperature increasing in the loop |
| 5. Pressure in the main steam header, more than 6,86 MPa  (70 kgf/cm2) | The reactor power level decreasing at core coolant flow decreasing |
| 6. De-energizing of one RCPS of three running ones | The reactor power decreasing using PP at core coolant flow decreasing. |
| 7. De-energizing of one RCPS of four running ones | The reactor power decreasing using PP at core coolant flow decreasing. |
| 8. Frequency at three of four RCPS feeding sections, les than 49 Hz | Ditto |
| 9. Tripping of the generator circuit breakers | The reactor power decreasing up to the level  40 % of nominal |
| 10. Tripping of one FWP of two functioning | The reactor power decreasing by PP at SG feed water flow decreasing |
| 11. Tripping of all FWPs | The reactor power decreasing by PP up to the level of 6 % of nominal with the loss of the feed water flow rate in SG |
| 12. Pressing PP-1 button at MCR | The reactor power decreasing by the operator at MCR |
| 13. The turbine tripping by steam (closing 2 of 4 TG SV) | The reactor power decreasing up to  the level 40 % of nominal |
| 14. TG load shedding up to house-load (tripping the circuit breakers of the main schematic diagram unit) | The reactor power decreasing up to  the level 40 % of nominal |

*APPENDIX A CONTINUATION*

Table А.2, continued

|  |  |
| --- | --- |
| Signal description | Result of the protection functioning |
| 15. Linear power-flux of maximally intensive FE is more than permissible one\* | The reactor power decreasing at local power-flux increasing |
| 16. Boiling margin at FE surface with maximal power-flux is less than the permissible one - 1,3 | The reactor power reducing at decreasing of the margin up to boiling crisis at FE surface |
| \* Note: the setpoint shall be calculated depending on position by the core height and FE type, in which maximum is reached | |

Table А.3 - List of preventive protection PP-2 signals

|  |  |
| --- | --- |
| Signal description | Result of the protection functioning |
| 1. Neutron flux density level within the startup range. The setpoint is variable, it shall be set in ratio 0,66Nvar of EP setpoint within the startup range | The reactor power level restriction at the Unit startup |
| 2. Pressure above the core, more than  16,2 MPa (165 kgf/cm2) | The reactor power level increasing restriction at unforeseen primary circuit coolant volume and temperature increasing |
| 3. Drop of one CPS control rod | The reactor power level increasing restriction based on conditions of non-exceeding the permissible core peaking value |
| 4. Period Т<40 sec in the startup range | The reactor power limitation at unforeseen decreasing of thermal neutron flux fluctuation period in the startup range |
| 5. Linear power-flux of maximally intensive FE is more than permissible one\* | The reactor power limitation at local power flux increasing |
| 6. The boiling margin at FE surface with maximal power-flux is less than the permissible one - 1,35 | The reactor power limitation at decreasing of the margin up to boiling crisis at FE surface |
| \* Note: the setpoint shall be calculated depending on position by the core height and FE type, in which maximum is reached | |

*APPENDIX A CONTINUATION*

Table А.4 – List of accelerated preventive protection signals

|  |  |
| --- | --- |
| Description of signal, factor | Result of the protection functioning |
| 1. Tripping of one or more of four operating RCPS with delay 1,4 sec | The reactor power decreasing at tripping one RCPS |
| 2. TG load shedding up to idling (the generator circuit breaker tripping) | The reactor power decreasing at tripping the generator circuit breaker |
| 3. The turbine tripping by steam (closing two of four TG SV) | The reactor power decreasing at closing two of four TG stop valves |
| 4. TG load shedding up to house-load (tripping the circuit breakers of the main schematic diagram unit) | The reactor power decreasing up to house-load |
| 5. Tripping of one FWP of two working with the time delay of 1,8 s | The reactor power decreasing at tripping of one FWP without activation of the standby pump |
| 6. Pressing APP button at the MCR | The reactor power decreasing by the operator at MCR |
| Note.  The speeded preventive protection is activated at the reactor power more and equal 75 % Nnom, at the reactor power less than 75 % Nnom., the reactor unloading shall be performed by PP-1 circuits. | |

# APPENDIX В

The design values of individual SIS (or their elements) parameters for normal operation of the Unit

Table В.1

|  |  |  |  |
| --- | --- | --- | --- |
| Parameter description | Lower limit | Nominal value | Upper limit |
| 1. YA, YC, YE – primary circuit |  |  |  |
| 1.1 Hydraulic test pressure (at least once in four years), MPa (kgf/cm2) |  | 24,5 (250) | 25,0 (255) |
| 1.2 Tightness test pressure (after each primary circuit unsealing), MPa, kgf/cm2 |  | 17,7 (180) | 17,7 (180) |
| 1.3 Time delay: |  |  |  |
| 1) at hydraulic tests, minutes;  2) at testing for tightness, hours | 10  1 | -  within the time required for testing | 60  4 |
| 1.4 Coolant temperature variation rate °С/hr: |  |  |  |
| 1) at heating-up  2) at cooling-down |  | 20  30 | 60 |
| 1.5 Primary circuit coolant temperature at hydraulic testing, °С | as per table 3.2.2.5.1 |  | 130 |
| 1.6 Primary circuit pressure variation rate, MPa/min (kgf/cm2 per minute) |  | less 0,98 (10) | 0,98 (10) |
| 1.7 At primary circuit heat-up - cool-down, margin up to coolant boiling up at FA outlet, °С | 15 | more than 15 |  |
| 1.8 Value of MCP pipelines thermal displacements comparing to the reference values obtained during commissioning, mm | Нnom−3 | Нnom | Нnom+3 |

| *APPENDIX В CONTINUATION* | | | |
| --- | --- | --- | --- |
| Table В.1, continued | | | |
| Parameter description | Lower limit | Nominal value | Upper limit |
| 2. ROM |  |  |  |
| 2.1 Power restriction level Nnom % at RCPS power supply frequency more than 49 Hz: |  |  |  |
| 1) at four running RCPS and two running FWP (at availability of additional limits for the permissible level of power for the current lifetime, the setpoint shall be set to value 102 % of the permitted level of power) |  |  | 102 |
| 2) at three running RCPS and two running FWP |  |  | 42 |
| 3) at two running RCPS in the opposite loops and two running FWP, or at one running FWP |  |  | 42 |
| 4) at tripping of one FP and non-activation of the standby FP by ALT with time delay 30 sec |  |  | 52 |
| 5) at two running RCPS in the adjacent loops and at least one functioning FWP |  |  | 42 |
| 6) at closing two of four stop valves |  |  | 42 |
| 7) at the Unit tripping from the power grid (Unit circuit breaker tripping) |  |  | 42 |
| 8) at tripping of the generator circuit breakers |  |  | 42 |
| 9) at tripping all FWP |  |  | 6±2  In compliance with TD No. 28.BU.1 0.YZ.AK.RT.ATEX1199 |
| 2.2 At frequency decreasing at three of four RCPS feeding sections up to 49 Hz, the power restriction level decreases up to 0,9 of the nominal power restriction level defined depending on the number of running RCPS and FWP at the nominal power supply frequency.  The reactor unloading shall be performed up to power value to 3 % below the power restriction level |  |  | 0,9Nnom |
| 3. YС – reactor |  |  |  |
| 3.1 Pressure in inter-sealing cave of the main joint seal, MPa (kgf/cm2) | - | 0 | 2,0 (20) |
| 3.2 CPS CR mismatching in the operating group, mm |  |  | 60 |
| 3.3 Maximal time of FA being in the reactor core, year |  |  | 5 |
| 3.4 CPS AR service life not more, eff. hr. including AC group |  |  | 75000  23000 |
| 3.5.1 Maximal time of FA operation (taking into account operation at power reactivity coefficient) not more than, eff.hr.  - at 1 year operation duration;  - at 3 year operation duration;  - at 4 year operation duration |  |  | 8000  22500  30000 |
| 3.5.2 Maximal duration of FA operation, fuel loads |  |  | 4 |
| 3.6 The reactor ICDS service life, years |  | 4 |  |
| 3.7 Ambient temperature of ICDS connectors at operation, °С |  |  | 115 |
| 3.8 Deviation of the reactor main joint surface from horizontal within the reactor service life on 4000 mm basis (incline 1:2500),not more mm | 0 | less than 2 | 2 |
| 3.9 Pressure differential at the reactor, MPa (kgf/cm2) |  | 0,38 (3,9) |  |
| 3.10 Temperature of the reactor upper unit outer surface, °С |  | 45 | 60 |
| 3.11 Minimal temperature of the reactor vessel wall at hydraulic tests for strength and tightness, °С | as per Table 3.2.2.5.2 |  |  |
| 4. RCPS |  |  |  |
| 4.1 Flow-rate (calculation by hydraulic characteristics at four running RCPS), m3/hr | 20000 | 22000 | 27000 |
| * 1. Off-line circuit temperature at the pump inlet, °С   during operation:  during standby: | 15  15 |  | 34  45 |
| 4.3 Off-line circuit temperature at the pump outlet, °С | 20 | 80 | 100 |
| 4.4 Pressure in the radial-axis pump bearing chamber, MPa (kgf/cm2) | 0,394  (4,0) | 0,56  (5,71) | 0,88  (9,0) |
| 4.5 Temperature in the radial-axis pump bearing chamber, °С | 20 | 65 | 70 |
| 4.6 Oil level in the oil tank, mm | 250 | 300 | 600 |
| 4.7 Oil temperature at the motor inlet , °С | 0 | 30 | 41 |
| 4.8 Oil pressure in the motor oil canister, MPa (kgf/cm2) | 0,02 (0,2) | 0,04 (0,41) | 0,1 (1,0) |
| 4.9 Oil pressure differential between the motor oil canister and the motor inlet, MPa (kgf/cm2) | 0,06 (0,61) | 0,08 (0,81) | 0,1 (1,0) |
| 4.10 RCPS thrust corresponding to the design point of RCPS characteristics at flow-rate 22000 m3/hr at water temperature 300 °С, MPa (kgf/cm2) | 0,563 (5,75) | 0,588  (6,00) | 0,613 (6,25) |
| 4.11 Pressure differential at RCPS, MPa (kgf/cm2) | 0,57 (5,81) | 0,62 (6,32) | 0,67 (6,83) |
| 4.12 The pump rotor displacement in the radial direction in the area of the radial-axis bearing, mm | 0,5±2,0 | | |
| 4.13 The pump rotor displacement in the radial direction in the area of sealing, mm | 0,5±2,0 | | |
| 4.14 Water flow-rate to the sealing from plant system, m3/hr | 0,75 | 0,9 | 1,2 |
| 4.15 Water pressure beyond the first sealing stage, MPa (kgf/cm2) | 0 (0) | 8,2  (83,6) | 17,6 (180) |
| 4.16 Water pressure differential between inlet and beyond the first sealing stage, MPa | 0,49 | 8,2 | 17,6 |
| 4.17 Vibration rate in the area of the upper motor cross, mm/sec | 0 | 4,5 | 7,1 |
| 4.18 Vibration rate in the area of the lower motor cross, mm/sec | 0 | 4,5 | 7,1 |
| 4.19 Vibration rate in the area of the radial-axis pump bearing, mm/sec | 0 | 7,1 | 11,2 |
| 4.20 Vibration rate in the area of the lower radial pump bearing, mm/sec | 0 | 4,5 | 7,1 |
| 5. YP – pressurizing system |  |  |  |
| 5.1 PRZ PSD activation conditions, MPa  1 PV opening start pressure  -reference PPD  -operating PPD  2 Closing pressure:  -reference PPD  -operating PPD |  | 18,1  18,6  16,7  16,7 |  |
| 5.2 Pressure in the inter-sealing caves of hatch seals, MPa (khg/cm2) | - | 0 | 0,1 (1) |
| 5.3 Pressure in the inter-sealing caves of TEH joint seals, MPa (kgf/cm2) | - | 0 | 0,1 (1) |
| 6. YB – steam-generator |  |  |  |
| 6.1 Steam capacity (with account for sensor reading error), t/hr |  | 1470 | 1570 |
| 6.2 Steam generator primary circuit coolant flow, m3/hr | 20000 | 21200 | 22200 |
| 6.3 Steam moisture, not more % mass. |  |  | 0,2 |
| 6.4 Pressure in the inter-sealing cave of SG header at leaking at the primary circuit side, MPa (kgf/cm2) | - | 0 | 2,0 (20) |
| 6.5 Pressure in the inter-sealing cave of SG header at leaking at the secondary circuit side, MPa (kgf/cm2) | - | 0 | 6,28 (64) |
| 6.6 Pressure in the inter-sealing cave of secondary circuit flanged joint gaskets, MPa (kgf/cm2) |  |  | 6,28 (64) |
| 6.7 Pressure in the inter-sealing cave of hatch seals, MPa (kgf/cm2) | - | 0 | 6,28 (64) |
| 6.8 Hydraulic resistance of the primary circuit steam-generator (design one at coolant flow 21500 m3/hr), not more MPa (kgf/cm2) | 0,12  (1,22) | 0,134  (1,37) | 0,146 (1,49) |
| 6.9 Hydraulic resistance of the secondary circuit steam-generator (design one at nominal steam capacity), not more MPa (kgf/cm2) |  |  | 0,11 (1,12) |
| 6.10 Permissible number of defective SG tubes withdrawn from operation, % of the total number |  |  | 2 |
| 7. YT – the emergency core cooling system (passive part) |  |  |  |
| 7.1 Pressure in the inter-sealing cave of the accumulator hatch gaskets, MPa (kgf/cm2) | - | 0 | 0,1 (1) |
| 7.2 ECCS HA level, mm | 6400 | 6500 | 6600 |
| 7.3 ECCS HA pressure, MPa (kgf/cm2) | 5,59 (57) | 5,88  (60) | 5,98 (61) |
| 7.4 ECCS HA water temperature, °С | 60 | 70 |  |
| 7.5 Mass concentration of boric acid, g/dm3 | 16 |  | 20 |
| 8. The emergency reactor protection system |  |  |  |
| 8.1 Time of CPS AR-adhered bar drop, from full height of operating motion by EP signal, sec | 1,2 | 1,2÷4 | 4 |
| 8.2 Rate of the bar with CPS AR displacement in control mode, mm/sec | 18,5 | 20 | 21,5 |
| 8.3 Effectiveness of CPS CR assembly operating group, %Кeff | 0,5 | 0,7 |  |
| 8.4 EP effectiveness within all range of RP parameters taking into consideration non-activation of one the most effective CPS CR at any moment of the lifetime, %Кeff  at MCL of power;  at level 50% Nnom;  at level 100% Nnom. | 3,3  5,1  5,5 |  |  |
| 9. TH – borated water storage system |  |  |  |
| 9.1 Low concentration borated water storage tanks TH10(20,30,40)B001,002 |  |  |  |
| 9.1.1 Borated water volume in the tank, m3 |  | 197,5 |  |
| 9.1.2 Temperature in the tank, °С: | 20 | 25 | 70 |
| 9.1.3 НзВОз concentration in the tank, g/dm3 | 16 | 16 | 20 |
| 9.2. 2nd stage ECCS HA TH16,17,26,27,36,37,46,47B001 |  |  |  |
| 9.2.1 Borated water volume in the accumulator, m3 |  | 34 |  |
| 9.2.2 НзВОз concentration in the tank, g/dm3 | 16 | 16 | 20 |
| 10 TJ – containment spray system |  |  |  |
| 10.1 Injected medium flow-rate from water-jet pumps TH10(20,30,40)D002, m3/hr |  | 10,0 |  |
| 10.2 Iodine chemical fixity tank TH10(20,30,40)B004:  1) volume, m3  2) chemicals composition:  boric acid concentration, g/dm3  potassium ions concentration, g/dm3  hydrazine-hydrate concentration, g/dm3 |  | 3,32  39,5-44,5  100 – 150  10 – 15 |  |
| 11. TH10(20,30,40) – low pressure residual heat removal system |  |  |  |
| 11.1 Water flow-rate from pump TH10(20,30,40)D001, not less, m3/hr:  1) at Рpc=1,0 MPa (10,2 kgf/cm2)  2) at Рpc =0,1 MPa (10,2 kgf/cm2) | 360  750 |  |  |
| 11.2 Water temperature at functioning of pumps, °С  1) from tanks  2) from the pit | 25 |  | 70 |
| 12. TH15(25,35,45) – high pressure injection system |  |  |  |
| 12.1 Water flow-rate from pumps TH15(25,35,45)D001, not less, m3/hr:  1) at Рpc =3,8 MPa (40 kgf/cm2)  2) at Рpc =7,06 MPa (72 kgf/cm2) | 200  40 |  |  |
| 12.2 Water temperature at functioning of pumps, °С  from tanks | 25 |  | 70 |
| 13. TW – extra borating system |  |  |  |
| 13.1 Water flow-rate from pumps TW10(20,30,40)D001, m3/hr | 7,2 | 7,2 | 7,2 |
| 13.2 Water temperature at functioning of pumps, °С | 20 |  | 40 |
| 13.3 НзВОз concentration in the tank, g/dm3 | 39,5 | 40 | 44 |
| 14. RS10,20,30,40 – emergency feed water system |  |  |  |
| 14.1 Volume of demineralized water tanks (RS10,20,30,40B001), m3 | 350 | 350 | 350 |
| 14.2 Temperature in tank (RS10,20,30,40B001), °С | 25 | 30 | 40 |
| 14.3 Water flow-rate in SG from EFWP (RS12,22,32,42D001), not less, m3/hr: | 129 | 150 | 150 |
| 15. RL – main feed water system |  |  |  |
| 15.1 Deaerator RF60B001:  1) capacity, t/hr  2) operating pressure, MPa (kgf/cm2), abs. |  | 6000  0,824 (8,4) |  |
| 15.2 Capacity of feed water pumps RL12,22,32D001, m3/hr |  | 2990 |  |
| 15.3 Flow-rate from AFWP to SG (RR12,22D001), m3/hr |  | 150 | 150 |
| 16. VE – service water supply system for cooling TF and VJ intermediate circuits |  |  |  |
| 16.1 Service water flow-rate to TF maintenance (TF10,20,30,40B001), m3/hr | 3010 | 3010 | 3010 |
| 16.2 Service water flow-rate to VJ maintenance (VJ10,20,30,40B001), m3/hr | 980 | 980 | 980 |
| 16.3 Cooling water temperature, °С | 20 | 20÷28 | 28 |
| 17. X – confinement |  |  |  |
| 17.1 Rarefication in the confinement, Pa | 150-275 | | |
| 17.2 Operating media parameters in the containment premises:  temperature, °С  humidity, % | 15 | 15÷33  90 | 60  90 |
| 17.3 Tilting of the confinement building and superstructure, mm for 1000 mm of basement |  | ≤0,001 | ≤0,003 (at special effects) |
| 17.4 Rarefication in the gap between shields Pa | 100 | 100÷400 | 400 |
| 17.5 Temperature in the gap between shells, °С | 15 | 15÷33 | 60 |
| 18. RA – main steam-line system |  |  |  |
| 18.1 SG SV parameters RA10(20,30,40)S001,002:  1) check valve opening pressure, MPa (kgf/cm2);  2) operating valve opening pressure, MPa (kgf/cm2);  3) check and operating valves closing pressure, MPa (kgf/cm2) |  | 8,24 (84)  8,44 (86)  6,87 (70) |  |
| 18.2 BRU-A parameters RA10(20,30,40)S003:   1. opening (closing) time, sec;   2) throughput capacity at full opening and pressure 7,154 MPa, t/hr |  | 900 | 15 |
| 18.3 MSIV parameters RA10(20,30,40)S004:  closing time, sec |  |  | 10 |
| 19. SF – turbine bypass system  (BRU-K) |  |  |  |
| 19.1 Quick acting turbine bypass valve  (SF11-16S001):  1) capacity, t/hr  2) activation time, с  3) opening start pressure, MPa (kgf/cm2)  4) closing start pressure, MPa (kgf/cm2) |  | 600  15  6,67 (68)  6,08 (62) |  |
| 20. TF - Reactor building intermediate circuit cooling water system |  |  |  |
| 20.1 Temperature after intermediate circuit maintenance (TF10,20,30,40B001), °С | 20 | 20÷33 | 33 |
| 20.2 Operating range of pump TF10(20,21,30,31,40)D001 supply, m3/hr | 900 |  | 1980 |
| 20.3 Closed circuit water activity after ECCS maintenance, Bq/m3:  - total  - by isotope Na-24 | 6×104  3×104 |  | 6×107  3×107 |
| 20.4 Closed circuit water activity in discharge pipeline from ZA building, Bq/m3  - total  - by isotope Na-24 | 6×104  3×104 |  | 6×107  3×107 |
| 21. TH – fuel pool cooling subsystem |  |  |  |
| 21.1 Water flow-rate at the cooling pump head (TH18,28,38,48D001), m3/hr |  | 600 |  |
| 21.2 Water temperature in the pool, °С | 20 | 40÷50 | 70 |
| 21.3 Boric acid concentration in the pool, g/dm3 | 16 | 16 | 20 |
| 21.4 Fuel pool level, m | 20,9 | 21,0 | 21,1 |
| 22. RZ – SG blow-down system |  |  |  |
| 22.1 Pressure in SG blow-down expander, MPa (kgf/cm2) |  | 1,1 (11,2) |  |
| 22.2 Level in blow-down expander, mm | 100 | 500 | 620 |
| 23. TA – make-up and blow-down system |  |  |  |
| 23.1 Make-up pumps (TA31,32,33D001):  capacity, m3/hr | 7 | 30 | 54 |
| 23.2 Difference between make-up and blow-down flow-rates in the steady state, m3/hr |  | 0÷2 | 3,5 |
| 23.3 Coolant temperature difference in primary circuit cold legs and make-up water | - | less than 30 | 30 |
| 24. TD – coolant storage and treatment system |  |  |  |
| 24.1 Pump (TD71,72,73D001):  nominal capacity / operating range, m3/hr |  | 54/30÷67,5 |  |
| 24.2 “Pure” condensate supply and TD system tanks recirculation pump (TD73D001):  nominal capacity / operating range, m3/hr |  | 50/30÷66 |  |
| 24.3 “Pure” condensate tanks (TD14,15,16B001):  capacity, m3 |  | 3×120 |  |
| 24.4 Boron-containing water tanks (TD11,12,13B001):  capacity, m3 |  | 3×120 |  |
| 25. TC60-90 – non-cooled primary circuit coolant cleanup system |  |  |  |
| 25.1. Pressure differential at filter, MPa (kgf/cm2) | 0 | <0,4 (4) | 0,5 (5) |
| 25.2. Pressure differential at filter-trap,  MPa (kgf/cm2) | 0 | <0,03 (0,3) | 0,1 (1) |
| 26. TS10 – hydrogen ignition system |  |  |  |
| 26.1 Hydrogen concentration after catalyst cases, % |  | 0÷0,3 | 0,3 |
| 27. TL,UV – ventilation and conditioning systems |  |  |  |
| 27.1 Ambient parameters in MCR and ECR premises:  1) temperature, °С  2) humidity, % | 15  58,5 | 20  60 | 25  61,5 |
| 27.2 Ambient temperature in NFME, I&C, ROM, EP, PP, PL premises, °С | 15 | 25 | 30 |
| 27.3 Air supply to the upper unit (PED drive):  1) flow-rate, m3/hr  2) temperature, °С | 40000  30 |  | 50 |
| 28. PL, PS, PT – equipment to be used for transportation-and process operations with FA, CPS AR, and BAR bundles at refueling |  |  |  |
| 28.1 Displacement speed:  1) horizontal, m/min  2) vertical, m/min | 0,3  0,3 |  | 15,0  10,0 |
| 28.2 Displacement speed near the equipment:  1) horizontal, m/min  2) vertical, m/min  3) vertical inside the packing set, m/min | 0,3 |  | 3,5  2,0  0,6 |
| 28.3 Refueling machine displacement rate:  1) horizontal, m/min  2) vertical, m/min  3) vertical in the core  4) vertical in DADS storage bottle, spent fuel pool rack cell, spent fuel container, as well as CPS AR and BAR bundle displacement in FA channels, m/min | 0,6  0,6 |  | 21  12,5  0,6  2,0 |
| 28.4 Pressing force to FA, n (kgf) |  |  | 9800 (1000) |
| 28.5 Jerking force developed by refueling machine bar, N (kgf) |  |  | 23000 (2350) |
| 28.6 Dragging force at operations with CPS AR and BAR bundles, N (kgf) |  |  | 1470 (150) |
| 28.7 FA weight exceeding or loss as the result of the adjacent FA friction during FA setting-withdrawal to/from the reactor core, n (kgf) |  |  | 735  (75) |
| 28.8 CPS AR and BAR bundle weight exceeding or loss at setting-withdrawal to/from FA, n (kgf) |  |  | 127  (13) |
| 29. TМ – compressed air supply system for pneumatic-driven valves |  |  |  |
| 29.1 Pressure in air-collector ТМ11B001, ТМ12B001, MPa (kgf/cm2) | 4,5  (45) | 5  (50) | 5,5  (55) |
| 30. VJ – Closed circuit system for safety-related consumers |  |  |  |
| 30.1 Operating range for pump VJ11(21,31,41)D001 supplies, m3/hr | 400 | 530 | 530 |
| 31. TY-1 – nuclear equipment drain system in reactor compartment |  |  |  |
| 31.1 Level in drainage tank ТY30В001, m | 0,5 |  | 2,4 |
| 31.2 Pressure in drainage tank ТY30В001 (excess), MPa |  | 0,005 over water column |  |
| 31.3 Operating range of pump TY31(32)D001 supplies, m3/hr | 7,5 | 7,5 - 28 | 28 |
| 32. TH50-70 – Fuel pool water discharge system |  |  |  |
| 32.1 Operating range of pump TH71(72)D001 supplies, m3/hr | 30 | 70 | 70 |
| 33. TХ10 – Boron-containing water leakages accumulation system |  |  |  |
| 33.1 Operating range of pump TХ10D001 supplies, m3/hr | 11 |  | 25 |
| 33.2 Level in boron-containing water leakages accumulation tank ТХ10В001, m | 0,1 |  | 0,8 |

# APPENDIX C

Figure C.1 – Graph of minimum pressure above the core, at which it is allowed to start up RCPS



# APPENDIX D

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Нprz, cm | |  |  |  |  |  |  | |  |  |  |
| 850 |  |  |  |  |  |  |  | |  |  |  |
| 817 |  |  |  |  |  |  | |  |  |  |  |
| 800 |  |  |  |  |  |  | |  |  |  |  |
| 750 |  |  |  |  |  |  | |  |  |  |  |
| 700 |  |  |  | 2 |  |  | |  |  |  |  |
| 650 |  |  |  |  |  |  | |  |  |  |  |
| 600 |  |  |  |  |  |  | |  |  |  |  |
| 550  510  500 | 1 |  |  |  |  |  | |  |  |  |  |

0 10 20 30 40 50 60 70 80 90 100 Nn, %

280 287 294 301 °С

1 – operation of level maintaining controller YPR10DL002

2 – operation of coolant mass balance maintaining regulator YPR10DL001

Note.

Regulator 2 shall be actuated at the reactor power (8÷10) % Nnom.

Figure D.1 – Nominal value of PRZ level depending on average primary circuit coolant temperature

# APPENDIX Е

Algorithms of the reactor power-flux distribution and power control

#### 1 Power-flux parameters

1.1 Power-flux parameters:

N – current reactor power (to be provided by MCDS).

Nnom – nominal reactor power (3000 MW).

Nperm – the reactor power, maximally-permissible at the current state of the equipment (defined in the Technical Specification).

Kqj – relative power of j-th FA power-flux, equal to its power ratio to average FA power (to be provided by MCDS).

Kvij – the core peaking factor – relative power-flux in a cell (i,j) of the core (i – height layer number, j – FA number) equal to the power-flux power ratio in this cell to the average power (to be provided by MCDS).

Kvijperm – maximally permissible Kvij value at power Nperm (to be provided by MCDS for each core cell for each loading).

Qlij – maximal linear thermal load to FE in the core cell (i,j), W/cm (to be provided by MCDS).

Qliдоп – maximally permissible value of the linear thermal load to FE i-th height layer (to be provided by MCDS, see fig.3).

AO – momentary axial offset meeting the current xenon distribution (to be provided by MCDS)

,

where NU and NL – are current power values of the upper and lower core halves, respectively (to be provided by MCDS); N= NU + NL – current full power.

АО\* – balanced axial offset meeting the balanced (steady) xenon distribution.

1.2 Power-flux limits

Limit of the core power integral power:

N≤Nperm.

Limit of local power flux at power N≤Nperm:

Kvij ≤ ψ Kvijperm,

where ψ=1/(0.83⋅N/Nperm+0.17)

and Kvij values are specified in item 3.2.1.8 of this specification.

Qlij ≤ Qliperm

The limits for offset are recommendations and shall be defined as offset-power phase diagram containing optimal phase tracks and the recommended area of the current phase point positions (see fig.E.5).

*APPENDIX E CONTINUATION*

2 Control actions

2.1 Change of boric acid concentration in the coolant (boron concentration) by injecting distillate or boric acid concentration using boron control system (BCS).

2.2 Change of individual CPS CR positions (from one to six) selected at the individual selection panel (ISP) by activating individual control key (ICK).

2.3 Change of control groups 8, 9 and 10 positions (fig.E.1) manually – by activating group control key (GCK) and/or automatically – due to APC functioning in «Т» or «N» mode.

Motion transmission between the groups is provided in the following way: at moving down – at 50% of the core height, at moving up – at 100% of the core height. The possibility to set any control group as APC operating group is provided. Manual control has higher priority (at receiving two signals for the group movement – from GCK and APC, GCK command shall be performed).

Groups 9 and 8 shall be inserted to the core at the reactor unloading and at xenon oscillations suppression. In the reactor steady state, groups 8 and 9 shall be extracted from the core, group 10 (operating) shall be within the range permissible for current power, at all levels of power the recommended range is 70-90 % (fig.E.2).

Displacement of the lower CPS CR end face in direction of the core mid-height, shall give negative increment of the offset value. At mutually compensating reactivity movement of two groups, increasing/decreasing of distance between them (vertical distance between CPS CR end faces) shall bring to positive/negative increment of the offset value.

During the groups movement control it is required to observe their regular sequence: H8>H9>H10.

2.4 Drop of the accelerated preventive protection (APP) group, extraction APP group.

2.5 Drop of all groups by the emergency protection signal.

2.6 Automated insertion of the groups in their regular sequence with motion transmission at 50 % of the core height, by PP-1 signal.

3 Informational support of the operator

The operator shall use the special means of the informational support based on data presented at TLSU AWS monitors on current status and prehistory of the reactor operation, as well as based on the design information allowing to predict the reactor’s behavior. MCDS includes DR (dummy reactor) program functioning in the real-time mode and providing the design prediction functions.

The core power-flux control-oriented information submission formats at MCDS monitors contain the following:

- the reactor power fluctuation diagrams, momentary and balanced offset values, CPS CR control group positions, average inlet temperature and the core coolant heat-up temperature;

- shape of axial core power distribution (average by the core and by individual FA), with the setpoint of regulatory limitation;

- core power distribution maps – Kqj and Kvij (by the core height layers);

*APPENDIX E CONTINUATION*

- offset-power and offset-offset phase diagrams;

- text messages (prompts, recommendations, cautions).

*Offset-offset phase diagram* (fig.E.4) is drawn up in axes of momentary (AO) and balanced (AO\*) offset. Momentary offset shall be defined in MCDS, it corresponds the current distribution of xenon concentration in the core at the current parameters of the reactor condition. The balanced offset corresponds to the balanced xenon distribution, it is automatically calculated in DR program. The points on the diagram diagonal (АО=АО\*) correspond to the steady modes of the reactor.

*Offset-power phase diagram* (fig.E.5)is drawn up in power axes (N) and momentary offset (AO). It contains the optimal phase tracks and the recommended area. At phase point displacement by the optimal track, the minimum of local linear thermal FE load fluctuations

(jumps) is provided. Maintaining the phase point in the recommended area limits the values of linear thermal load jumps within the permissible range.

If required, the operator shall request the estimated prediction of the reactor behavior using DR program.

4 Xenon oscillations

Xenon oscillations of the core power distribution are caused by periodic redistribution process of iodine, xenon concentrations and neutron flux density by the core volume. Axial xenon oscillations (offset oscillations) and diametric xenon oscillations may be of practical importance for the reactor operation.

4.1 Offset xenon oscillations

Offset fluctuation at the constant reactor power and absence of control actions (offset drift) confirms availability of xenon oscillations of the axial core power distribution. Offset increasing/decreasing is «ascending»/«descending» phase of oscillations. Offset oscillations have (AO) have sinusoidal shape relatively the balance point – balanced offset (AO\*), with the period T~28 hours. At the beginning of the lifetime the oscillations are damping, at the end of the lifetime they are spreading. If values of current deviation А=АО-АО\* and offset drift rate А′ are known, then the oscillation amplitude Аmax for the nearest extremum (without taking into consideration damping) shall be estimated by the formula:



The main reasons for offset xenon oscillations initiation:

*Initial offset disturbance*. Positive/negative offset increment excites ascending/descending oscillation phase.

*CPS CR displacement.* Change in CPS CR groups position introduce initial offset disturbance, which is the reason for xenon oscillations development. If by a group displacement offset disturbance is introduced in the phase with already existing oscillations, it shall increase their intensiveness.

*APPENDIX E CONTINUATION*

*Power decreasing.* Power decreasing at unchanged CPS CR position causes initial offset increasing and ascending oscillation phase, if offset increasing is compensated by CPS CR group insertion, then the initial phase of xenon oscillations is defined by the initial shape of the axial iodine distribution. Immediately after power decreasing, the processes of iodine decay and xenon concentration dominate. For initial steady state with negative/positive offset value, power decreasing excites ascending/descending phase of the xenon oscillations. At the initial availability of xenon oscillations, power decreasing cause their intensiveness (maximally – at the points of the offset time schedule discontinuity (AO=AO\*), minimally – at the points of the extremum).

*Power increasing.* Power increasing at unchanged CPS CR position causes initial offset decreasing and descending oscillation phase. Immediately after power increasing, xenon burnout process dominates. Xenon oscillation phase is defined by the offset fluctuation: negative/positive offset increment excites descending/ascending phase of the xenon oscillations.

4.2 Diametric xenon oscillations

Asymmetric Kqj increasing in an individual FA group and corresponding Kqj decreasing in the diametrically opposite part of the core, at the constant reactor power and absence of the control actions confirm availability of diametric xenon oscillations.

The main reasons for diametric xenon oscillations initiation:

Asymmetric CPS CR displacement, in particular, drop of one CPS CR or extraction of the previously dropped CPS CR.

Activation of RCPS at previously idling loop.

5 Control algorithms in normal operation conditions

5.1 Operation at constant power

5.1.1 Constant power level maintenance

Fuel burnout shall be automatically compensated by the operating group extraction using APC. TO maintain the constant offset value, the operator shall periodically bring the group to the initial position, decreasing boron concentration for this purpose.

5.1.2 Elimination of exceeding maximally permissible values of Kvij andQlij

Current and permissible values of Kvij and Qlij in each axial layer shall be controlled by the operator using the special MCDS format. Upon increasing Kvij and/or Qlij up to the values exceeding the maximally permissible ones (see item 1), the operator shall perform the following actions.

5.1.2.1 If maximal Kvij and/or Qlij are reached in the lower half of the core, the operator shall decrease the reactor power until reaching the permissible values by increasing boron concentration; if during this process the required decreasing of Kvij and/or Qlij occurred, the former power level shall be recovered by sequential extraction of the operating group (not higher than the upper maximally permissible position) and boron concentration decreasing.

5.1.2.2 If maximal Kvij and/or Qlij are reached in the upper half of the core, the operator shall decrease the reactor power until reaching the permissible values by the operating group insertion; if during this process the required decreasing of Kvij and/or Qlij occurred, the former power level shall be recovered by decreasing boron concentration.

*APPENDIX E CONTINUATION*

5.1.2.3 If as the result of actions on elimination of the maximally permissible Kvij values exceeding, the offset xenon oscillations have been excited, the operator shall perform suppression of oscillations in compliance with item 5.1.4.

5.1.3 Suppression of the offset xenon oscillations

5.1.3.1 Using the offset time schedule and phase diagrams presented at MCDS monitors, the operator shall estimate the degree of the reactor instability (define current amplitude and offset oscillations phase), predict possibility of overrunning the recommended area of the offset-power diagram by the phase point or possibility of exceeding the maximally permissible values of power-flux parameters, if required, the procedure of xenon oscillation suppression shall be started.

5.1.3.2 The general rule for oscillations preventing: at the reactor condition variation, the minimal offset deviation form the value corresponding to the final steady state shall be provided.

5.1.3.3 The general rule for oscillation suppression: the control action shall change the offset in direction opposite to its drift, between the control actions the time delays shall be made in order to define the direction and rate of the offset drift.

5.1.3.4 To suppress the ascending oscillation phase, the operator shall decrease boron concentration, at the same time APC shall insert group 10. If by inserting group 10 to 70% the oscillations are not suppressed, by actuating GCK the operator shall insert group 9 to position not lower than 80%, if required, group 8 shall also be inserted up to position not less than 90%. When the groups reach the limit bottom positions, the operator shall terminate oscillations suppression, further he shall control possible exceeding the permissible values of Kqmax and Kvij up to the moment of oscillation phase change to the descending one.

5.1.3.5 To suppress the descending phase of oscillations, the operator shall extract groups 8 and 9 up to USS by decreasing the boron concentration, and group 10 shall be extracted not higher than the maximal upper position (by GCK activation or using sequential setting of groups 8, 9 and 10 as APC operating group).

5.1.3.6 After the reactor unloading by means of groups (see item 5.2.1.2), when one of the control rod groups is in the lower half of the core, the other is in the upper half, to suppress ascending/descending phase of oscillations, it is recommended to switchover APC to the lower group control and by activating GCK insert/extract the upper group, at the constant boron concentration in the coolant. Decreasing/increasing of the group distance shall provide for the required offset decreasing/increasing.

5.1.3.7 In order to minimize water-exchange, to compensate for groups extraction at the descending oscillation phase suppression, it is allowed to insert the central CPS CR to the core (below 50%). After changing the oscillation phase, the central CPS CR shall be extracted, thus compensating for the groups insertion.

5.1.3.8 Changing the oscillation phaseto speedup oscillation suppression at the phase point drifting on the offset-offset diagram in direction – «from diagonal». The operator shall displace the rod groups due to changing boron concentration, effecting to the offset until the drift direction is changed – «to diagonal».

*APPENDIX E CONTINUATION*

5.1.3.9 Algorithm for maintaining the constant offsetprovides for the reactor condition stabilizing at the defined operating rod group position. By changing boron concentration, the operator displaces the control rod groups providing for the constant offset maintenance (corresponding to the defined position of the operating rod group) unit the oscillations are completely damped.

5.1.3.10 Algorithm for maintaining the balanced offsetprovides forthe quickest oscillation damping. Oscillation suppression shall be started at the moment, when the phase point reaches the diagonal of offset-offset diagram (АО=АО\*). By changing boron concentration, the operator displaces the control rod groups providing for maintaining the operating point at the

diagonal of offset-offset diagram unit the oscillation are completely damped (final positions of the rod groups are not predefined).

5.1.3.11 Upon reaching the maximal values of Kvij and/or Qlij, the operator shall perform actions as per item 5.1.2 respectively.

5.1.4 Suppression of diametric xenon oscillations

If the operator predicts the possibility of exceeding the maximally permissible value of j-th FA power during the diametric xenon oscillations, by displacing of one CPS CR closest j-th FA, he shall prevent exceeding of the maximally permissible FA power value and provide for oscillation suppression. CPS CR displacement shall be compensated by movement of the operating rod group or changing the boron concentration.

5.2 Power variation

Beforehand, using DR program, prediction of the final reactor condition shall be made, and also final position of the operation rod group shall be selected and final offset steady value shall be defined. It is recommended to select the final point of the phase track on the offset-power diagram close to the optimal phase track passing via the initial point.

5.2.1 Power decreasing upon reaching the steady state

5.2.1.1 Power decreasing by boron

Power reducing*.* The operator shall decrease the reactor power by boron concentration increasing; I&C-TC maintaining pressure in MSH automatically decreases the electric power. If necessary, by the operating rod group insertion, the operator shall decrease offset up to the defined final value.

Operation at the decreased level of power*.* By changing boron concentration, the operator shall displace the operating rod group stabilizing offset at the defined final value (boron concentration change compensates transfer to the steady poisoning corresponding to the new level of power, the group shall be transferred to the final position).

5.2.1.2 Power reducing by groups

Power reducing

Method-1**.** By inserting the groups in the regular sequence, the operator shall decrease the reactor power; TG I&C maintaining pressure in MSH automatically decreases the electric power.

Method -2*.* TG I&C decreases TG electric power at the defined rate; APC maintaining pressure in MSH unloads the reactor by insertion of the control rod groups in the regular sequence – 10, 9, 8.

*APPENDIX E CONTINUATION*

Operation at the decreased level of power*.* At the stage of poisoning, APC extracts the groups in the regular sequence – 8, 9, 10; by correcting movement of groups (by way of changing their distance or boron concentration), the operator shall restrict development of the offset xenon oscillations. At the stage of de-poisoning, the operator shall stabilize the offset at the defined value using algorithm of the xenon oscillation suppression (item 5.1.4).

5.2.1.3 The methods of power decreasing by boron and groups may be used jointly.

5.2.1.4 If during operation at the decreased level of power, at least one of the control rod groups is in the lower half of the core, it is forbidden to inject distillate to compensate for insertion of groups in order to control the offset (it is recommended to use group distance changing).

5.2.1.5 The permissible rates of the reactor power variation shall not exceed the values specified in Table 3.2.2.

5.2.2 Power increasing upon approaching the steady state

5.2.2.1 Power increasing shall be performed due to CPS CR groups extraction (groups 8 and 9 shall be extracted up to the upper stop switch of the core, the operating group – up to upper maximally permissible position) and boron concentration decreasing in the coolant.

When using both control actions, first of all the operator shall extract the groups, then decrease boron concentration (simultaneous introducing of the positive reactivity by two different systems is forbidden).

5.2.2.2 After initial power increasing by extraction of groups and boron concentration decreasing, further power increasing can be performed by the reactor de-poisoning (xenon burnout). It is recommended to use this technique at the final stage of power increasing.

5.2.2.3 If initial power was lower 75%, then «intermediate» power interval 75-85% shall be passed within not less than 3 hours. At the same time the operator shall select the method of de-poisoning compensation depending on the purpose of control optimization.

5.2.2.4 After reaching the defined power level, the operator shall stabilize offset at the defined final value using xenon oscillation suppression algorithms (item 5.1.4).

5.2.2.5 The permissible rates of the reactor power variation shall not exceed the values specified in Table 3.2.1.6.1.

5.2.3 Short-term power decreasing

5.2.3.1 Power decreasing shall be performed as per item 5.2.1.

5.2.3.2 Power increasing shall be performed as per item 5.2.2.

5.2.3.3 To prevent occurrence of the xenon oscillations, the following is recommended: after power decreasing, by xenon poisoning completely extract control rod groups 8 and 9, and group 10 move to a position providing the offset value close to the initial one; further perform compensation of xenon processes and power increasing by changing boron concentration, group 10 displacement and maintain initial offset value.

5.2.3.4 At power decreasing for the time less than 12 hours, it is allowed to maintain the groups close to the position reached during unloading, thus providing possibility to increase power by extraction of groups. Xenon processes are compensated by changing boron concentration, offset control – due to changing group distances as per item 2.3.

5.2.3.5 At short-term (not more than 5 hours) reactor unloading from nominal power Nnom to N power within the range of 75-90%, the algorithm of «spatial localization of xenon processes» providing minimal water-exchange shall be used. The operator shall decrease the reactor power by dipping two groups 10 and 9 to the upper half of the core in a way, keeping the power of the lower part. For this purpose, the offset shall be decreased from initial value АО to value ~ АОlow, where АОlow=100+(AO-100)Nnom/N.

At the decreased power, the poisoning shall be compensated by extraction of the groups, by changing the distance of the groups the offset value ~АОlow shall be maintained. If required, boron concentration shall be changed.

Power increasing shall be performed by extracting the groups: group 9 shall be extracted completely, group 10 – up to position not higher the permissible one. If extraction of the groups failed to provide power increasing up to 100%, further power increasing shall be performed by the reactor de-poisoning or distillate injection. During operation at 100% of power, the constant final offset value shall be maintained.

6 Control algorithms in case of disturbances in normal operation conditions

6.1 Power reducing in manual mode

If in case of disturbances in normal operation the operator shall reduce the reactor power, he shall perform actions described in item 5.2.1.

6.2 Preventive protection activation

By PP-1 signal, the reactor shall be automatically unloaded by CPS CR groups insertion in the regular sequence. After cancelling the mode PP-1, the reactor control algorithms described in item 5.2 shall be used after power decreasing.

6.3 APP mode

By APP signal, automatic drop of pre-selected rod group shall take place simultaneously with groups insertion in PP-1 mode, as the result, power shall decrease up to the defined value. After the Unit unloading, the operator shall extract APP group from the core by xenon poisoning, boron concentration increasing, insertion of the operating or 9th group. Further, the reactor control algorithms described in item 5.2.1 shall be used after power decreasing.

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|  |
| --- |
| 1 158 15 1 16 163 |
| 2 149 150 151 152 153 154 155 156 157  **8** |
| 3 139 140 141 142 143 144 145 146 147 148  **9** **9** |
| 4 128 129 130 131 132 133 134 135 136 137 138  **10** |
| 5 116 117 118 119 120 121 122 123 124 125 126 127  **8 8** |
| 6 103 104 105 106 107 108 109 110 111 112 113 114 115  **10 8 10** |
| 7 89 90 91 92 93 94 95 96 97 98 99 100 101 102 |
| 8 76 77 78 79 80 81 82 83 84 85 86 87 88  **9** **9 8 9** |
| 9 62 63 64 65 66 67 68 69 70 71 72 73 74 75 |
| 10 49 50 51 52 53 54 55 56 57 58 59 60 61  **10 8 10** |
| 11 37 38 39 40 41 42 43 44 45 46 47 48  **8 8** |
| 12 26 27 28 29 30 31 32 33 34 35 36  **10** |
| 13 16 17 18 19 20 21 22 23 24 25  **9 9** |
| 14 7 8 9 10 11 12 13 14 15  **8** |
| 15 1 2 3 4 5 6 |

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16 . 18 . 20 . 22 . 24 . 26 . 28 . 30 . 32 . 34 . 36 . 38 . 40 . 42

17 19 21 23 25 27 29 31 33 35 37 39 41

№ FA

№ CPS

No. of FA – number of FA

No. of CPS – number of CPS CR control group

## Figure Е.1 - Position of CPS CR control groups

*APPENDIX E CONTINUATION*

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Н10, %  100  90  80  70  60  50  40  30  20  10  0 |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |
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|  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |
| 0 10 20 30 40 50 60 70 80 90 100  N, % |  |  |  |  |  |  |  |  |  |  |

- area of the recommended positions

- area of the permissible positions

Figure Е.2 - Permissible and recommended positions of CPS CR operating group at the reactor steady states

*APPENDIX E CONTINUATION*



Ql perm, W/cm

Figure Е.3 - Dependence of the maximal liner thermal load values (Ql)   
on the core layer height (H)

*APPENDIX E CONTINUATION*



|  |  |
| --- | --- |
| Фазовая траектория | Phase track |
| Диагональ – множество стационарных состояний | Diagonal – set of steady states |

Figure Е.4 - Offset-offset diagram

*APPENDIX E CONTINUATION*



|  |  |
| --- | --- |
| Фазовая траектория | Phase track |
| Рекомендуемая область | Recommended area |
| Оптимальные фазовые траектории | Optimal phase tracks |

Figure Е.5 - Offset-power diagram

# APPENDIX F

Norms of primary and secondary water chemistry in different operation modes.

1 Primary circuit water chemistry norms.

1.1 During the Unit power operation, alkalescent reductive ammonia-potassium water chemistry with the boric acid shall be used in the primary circuit.

#### 1.1.1 Primary circuit water chemistry shall provide for:

1) suppression of coolant radiolysis oxidizing products formation during the Unit operation at power;

2) corrosion resistance of the equipment and pipeline structural materials within all design operation period of NPP;

3) minimal quantity of sediments at FA surfaces in the core and heat-exchanging surface of the steam-generators;

4) minimizing of the activated corrosion accumulation.

#### 1.1.2 Suppression of coolant radiolysis oxidizing products formation is provided by hydrogen concentration maintenance within the range of permissible values by continuous or periodic feeding of ammonia or hydrazine-hydrate radiolytically decomposing with forming of hydrogen and nitrogen.

#### 1.1.3 Reducing of sediment increasing process intensiveness at the heat-exchanging surfaces and accumulation of activated corrosion at the primary circuit equipment surfaces during the Unit power operation is provided by maintaining the summary molar concentration of alkali element ions (potassium, lithium and sodium) in compliance with their optimal coordinated dependence on the current boric acid concentration.

#### 1.1.4 Coolant quality norms include ranges of the rated values as well as permissible deviations of the rated indices and levels of values for diagnostic indices.

#### 1.1.5 The rated indices are coolant quality indices maintaining of which within the range of permissible values provides for integrity of the fuel assemblies in the reactor core, the design lifetime of the primary circuit equipment safety operation and satisfactory radiation situation at the Unit.

#### 1.1.6. Deviations of the rated coolant quality indices are subdivided into levels. For each level both the maximal coolant quality indices deviations are established, and the maximally-permissible operation time of the Unit at deviations of the rated coolant quality indices. At deviation of the rated indices, the works shall be performed on revealing and eliminating of reasons for deviations.

1.1.7 Counting of the Unit operation time at the levels of actions specified in this document shall be started at the moment of recording the coolant quality indices deviation.

1.1.8 The diagnostics indices are the coolant quality indices providing for obtaining additional information on the reasons for changes of the rated indices or water chemistry deterioration. The diagnostics indices, except for boric acid concentration, include also make-up water quality indices, spent fuel pool and inspection cavity water quality indices, RP safety systems boric acid solution quality indices, as well as demineralized water and distillate quality indices. Deviations of the diagnostic indices from the reference levels point out the malfunctions in functioning of the process systems providing water chemistry, which in case of long-term effect may cause damaging of the fuel assemblies in the reactor core.

*APPENDIX F CONTINUATION*

1.1.9 At deviations of the rated and diagnostic coolant quality indices, the reasons for deviations shall be found out and eliminated.

1.1.10 The following shall be considered as water chemistry disturbance:

one or several rated coolant quality indices reached the maximum values corresponding to the third level of deviations during the Unit power operation ≥30% Nnom, and to the second level of deviations when the Unit is in “hot” condition, in the “reactor is at MCL of power” condition, or at power operation <30% Nnom;

#### non-fulfillment of the requirement on transferring the Unit to “cold” condition or «reactor is at MCL of power» condition when the rated indices reached the values at which it is required;

#### deviations of the diagnostic coolant quality indices from the levels of values, which have not been eliminated within 7 days starting from the moment of their reveal;

#### deviations of the diagnostic make-up water quality indices (except for solute oxygen and chloride-ion concentration), as well as auxiliary systems water and borated solutions of RP safety systems, which have not been eliminated within 7 days starting from the moment of their reveal;

#### deviations from solute oxygen or chloride-ion concentration in make-up water, which have not been eliminated within one day starting from the moment of their reveal.

1.1.11 Failure to eliminate deviations in diagnostic indices within the period of time specified in item 1.1.10 shall be recorded as water chemistry disturbance and be accompanied by the obligatory investigation of reasons caused disturbance with the investigation report executed.

1.1.12 Primary circuit chemical control data shall be stored at the nuclear power plant within 10 years. Chemical control data obtained during the periods of the primary circuit water chemistry disturbance shall be retained at the nuclear power plant till the Unit decommissioning.

1.1.13 The values of chemical quality indices correspond to the results of the analyzed water samples measurement or recalculation for the standard conditions:  
temperature - 25°С, pressure - 0.1 MPa (1.02 kgf/cm2).

1.2. Coolant quality norms and levels of deviations from rated values during Unit power operation >50% Nnom are specified in Table F.1.

1.2.1 Mass concentration of the boric acid shall be maintained depending on the reactor core reactivity margin.

1.2.2 Summary molar concentration of the alkali elements (potassium, lithium and sodium) shall be maintained depending on the current boric acid concentration within zone А, specified in Figure F.1.

#### 1.2.3 Ammonia concentration in the coolant shall be maintained at the level providing for hydrogen concentration within the range from 2.2 to 4.5 mg/dm3.

#### 1.2.4 Non-cooled coolant cleanup system (ТС60-90) filters and primary circuit blow-down water treatment system (ТС) filters shall function continuously providing their required flow-rate.

#### 1.2.5 During the Unit power operation, the fuel pool water quality indices shall correspond to the values specified in Table F.4.

*APPENDIX F CONTINUATION*

Table F.1 –Coolant quality norms during Unit power operation >50% Nnom:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| *Rated indices* | | | | | |
| Description of | Rated value | Level of deviation from the rated value | | | |
| indices |  | 1st level (7 days) | 2nd level (24hr→MCL) | | 3rd level (c.c.) |
| Mass concentration of chloride-ion, mg/dm3 | not more than 0.1 | - | over 0,1 to 0,2 | | over 0,2 |
| Mass concentration of solute oxygen, mg/dm3 | not more than 0.005 | over 0.005 to 0.02 | over 0.02 to 0.1 | | over 0.1 |
| Mass concentration of solute hydrogen, mg/dm3 | 2.2÷4.5 | over 4.5 to 7.2 or less than 2.2 to 1.3 | over 7.2 to 9.0 or less than 1.3 to 0.5 | | over 9.0 or less than 0.5 |
| Summary molar concentration of alkali elements (К+Li+Na) (depending on the current concentration of boric acid) in Fig. F1 | Zone А | Zones B and C | Zones D and E | | Zone F |
| *Diagnostic indices* | | | | | |
| Description of indices | | | | Value level | |
| рН value | | | | 5.8÷10.3 | |
| Ammonia mass concentration, mg/dm3, not less | | | | 5.0 | |
| Conductivity, µS/cm | | | | 20-150 | |
| Fe mass concentration, mg/dm3, not more | | | | 0.05 | |
| Fluoride-ion mass concentration, mg/dm3, not more | | | | 0.1 | |
| Sulphate-ion mass concentration, mg/dm3, not more | | | | 0.1 | |
| Total organic carbon mass concentration, mg/dm3, not more | | | | 0.5 | |

*APPENDIX F CONTINUATION*

**Summary molar concentration of alkali elements (K, Li, Na) ions in the coolant, mmole/dm3**

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**0.50**

**0.55**

**0.60**

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**Optimal mode line**

**Zone E**

**Zone А**

**Zone B**

**Zone D**

**Zone F**

**Zone C**

**Boric acid mass concentration, g/dm3**

Figure F.1 – Dependence of the summary molar concentration of alkali elements (K+Li+Na) in the primary circuit coolant on the current boric acid concentration:

Zone А range of rated values.

Zones B and C the first level of deviations.

Zones D and E the second level of deviations.

Zone F the third level of deviations.

*APPENDIX F CONTINUATION*

#### 1.3 Coolant quality norms and levels of deviations from the rated values during Unit power operation from 30 to 50% Nnom are specified in Table F2.

#### 1.3.1 Mass concentration of the boric acid shall be maintained depending on the reactor core reactivity margin.

#### 1.3.2 Summary molar concentration of alkali elements (potassium, lithium and sodium) shall be maintained depending on the current concentration of boric acid within zone А specified in Figure F.1.

#### 1.3.3 Ammonia concentration in the coolant shall be maintained at the level providing for the hydrogen level from 1.3 to 4.5 mg/dm3.

#### 1.3.4 Non-cooled coolant cleanup system (ТС60-90) filters and primary circuit blow-down water treatment system (ТС) filters shall function continuously providing their required flow-rate.

#### 1.3.5 In the course of Unit power operation at 30 to 50% Nnom, fuel pool water quality indices shall correspond to the values specified in Table F.4.

Table F.2 - Coolant quality norms during Unit power operation at 30 to 50% Nnom:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| *Rated indices* | | | | | |
| Description of indices | Rated value | Level of deviation from the rated value | | | |
| 1st level (7 days) | | 2nd level (24hr→MCL) | 3rd level (c.c.) |
| Mass concentration of chloride-ion, mg/dm3 | not more than 0.1 | - | | over 0.1 to 0.2 | over 0.2 |
| Mass concentration of solute oxygen, mg/dm3 | not more than 0.005 | over 0.005 to 0.02 | | over 0.02 to 0.1 | over 0.1 |
| Mass concentration of solute hydrogen, mg/dm3 | 1.3÷4.5 | over 4.5 to 7.2 | | over 7.2 to 9.0 or less than 1.3 to 0.5 | over 9.0 or less than 0.5 |
| Summary molar concentration of alkali elements (К+Li+Na) (depending on the current concentration of boric acid) in Figure F.1 | Zone A | Zones B and C | | Zones D and E | Zone F |
| *Diagnostic indices* | | | | | |
| Description of indices | | | Reference level | | |
| рН value | | | 5.8÷10.3 | | |
| Ammonia mass concentration, mg/dm3, not less | | | 15.0 | | |
| Conductivity, µS/cm | | | 20-200 | | |
| Fe mass concentration, mg/dm3, not more | | | 0.05 | | |
| Fluoride-ion mass concentration, mg/dm3, not more | | | 0.1 | | |
| Sulphate-ion mass concentration, mg/dm3, not more | | | 0.1 | | |
| Total organic carbon mass concentration, mg/dm3, not more | | | 0.5 | | |

*APPENDIX F CONTINUATION*

#### 1.4 Coolant quality norms in the course of Unit operation in “hot” condition, in the «reactor is at MCL of power» condition, and at power operation <30% Nnom, are specified in Table F.3.

#### 1.4.1 Upon exceeding solute oxygen concentration over 0.02 mg/dm3, hydrazine-hydrate shall be fed to the make-up water from TB system in the amount providing for at least twice hydrazine-hydrate excess in relation to the actual level of oxygen concentration in the coolant.

#### 1.4.2 In “hot” condition at the Unit startup, the lower margin of рН value shall be not less than 4.2.

#### 1.4.3 At the Unit startup after SPM, ammonia concentration in the coolant shall be maintained within the range of 20÷30 mg/dm3.

#### 1.4.4 Filters of non-cooled coolant cleanup systems (ТС60-90) and primary circuit blow-down water treatment system (ТС) shall be functioning continuously at providing their required flow-rate.

#### 1.4.5 During the Unit operation in "hot" condition, in the “reactor is at MCL” condition, and at power operation <30% Nnom, fuel pool water quality indices shall correspond to the values specified in Table F.4.

Table F.3 – Coolant quality norms when the Unit is in "hot" condition, in the «reactor is at MCL» condition, and at power operation <30% Nnom.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| *Rated indices* | | | | |
| Description of indices | Rated value | Level of deviation from the rated value | | |
| 1st level (24h→c.c.) | | 2nd level (c.c.) |
| Mass concentration of chloride-ion, mg/dm3 | not more than 0.1 | over 0.1 to 0.2 | | over 0.2 |
| Mass concentration of solute oxygen, mg/dm3 | not more than 0.02 | over 0.02 to 0.1 | | over 0.1 |
| Summary molar concentration of alkali elements (К+Li+Na) (depending on the current concentration of boric acid) in Figure F.1 | Zones A, B, C, D, E | - | | Zones F |
| *Diagnostic indices* | | | | |
| Description of indices | | | Reference levels | |
| рН value | | | 5.8÷10.3 | |
| Ammonia mass concentration, mg/dm3, not less | | | 15.0 | |
| Conductivity, µS/cm | | | 20-200 | |
| Fe mass concentration, mg/dm3, not more | | | 0.05 | |
| Fluoride-ion mass concentration, mg/dm3, not more | | | 0.1 | |
| Sulphate-ion mass concentration, mg/dm3, not more | | | 0.1 | |
| Total organic carbon mass concentration, mg/dm3, not more | | | 0.5 | |

*APPENDIX F CONTINUATION*

#### 1.5 Operational limits in the periods of the rated coolant quality indices deviations, when the Unit operates at the energy levels of power.

#### 1.5.1 Actions to be taken in case of deviations in the rated coolant quality indices at Unit power operation more than 50%Nnom.

#### 1.5.1.1 First level.

#### Permissible duration of the Unit operation at the power level equal or more than 30% Nnom when deviation in one or several rated indices specified in Table F.1 takes place within the first level shall not exceed 7 days from the moment of deviation reporting.

Failure to reveal the reasons and eliminate the deviations from the rated indices within 7 days, shall be recorded as water chemistry disturbance and be accompanied by the obligatory investigation of the reasons caused disturbance with the investigation report executed. The investigation report shall contain a program of corrective activities for elimination of disturbance, and preventive recommendations. The Unit operation can be continued with no reduction of power needed.

The total duration of the Unit operation with deviations in the rated index of summary concentration of alkali element ions (B and C zones) shall not exceed 30 days per the Unit operation fuel cycle.

#### 1.5.1.2 Second level.

Duration of the Unit power operation at power level more than 50% Nnom when deviation in one or several rated indices specified in Table F.1 takes place within the second level shall not exceed 24 hours from the moment of deviation reporting. If deviations in rated indices are not eliminated within 24 hours, the Unit shall be transferred to the “reactor is at minimally-controlled level of power” condition on the scheduled basis. Further increase of the Unit power is allowed after elimination of reasons caused deviation and restoring of indices up to the rated values specified in Table F3.

The total duration of the Unit operation with deviations in the rated index of chloride-ion concentration within the second level shall not exceed 5 days per the reactor operation fuel cycle.

#### 1.5.1.3 Third level.

The Unit shall be transferred to “cold” condition in a standard technological order when coolant quality rated indices reach the values of the third level of deviations specified in Tables F.1. At this, measures shall be taken to mitigate the violations in water chemistry.

#### 1.5.2 Actions to be taken in case of deviations in the rated coolant quality indices at the Unit power operation from 30 to 50% Nnom.

#### 1.5.2.1 First level.

As in item 1.5.1.1

#### 1.5.2.2 Second level.

As in item 1.5.1.2

#### 1.5.2.3 Third level.

As in item 1.5.1.3

#### 1.5.3 Actions to be taken in case of deviations in the rated coolant quality indices when the Unit is in “hot” condition, in the «reactor is at MCL of power» condition, or at power less than 30% Nnom.

*APPENDIX F CONTINUATION*

#### 1.5.3.1 First level.

Permissible duration of the Unit operation with the reactor plant in “hot” condition, in the “reactor is at MCL of power” state and at power operation less than 30% Nnom, when deviation in one or several rated indices specified in Table F3 takes place within the first level, shall not exceed 24 hours from the moment of deviation reporting. If within 24 hours the deviations of the rated indices were not mitigated, the Unit shall be switched over to the «cold» state in a normal process order, and measures shall also be taken to mitigate the violations of water chemistry.

#### 1.5.3.2 Second level

When one or several indices reach the values of the second level as specified in Table F.3, the Unit shall be switched over to the «cold» state in a normal process order, and measures shall also be taken to mitigate the violations of water chemistry.

#### 1.6 The Unit cool-down, "cold" condition of the Unit, and "shutdown for repair" or "refueling" condition.

#### 1.6.1 In order to decrease coolant hydrogen concentration to not less than 1.3 mg/dm2, injection of ammonia or hydrazine-hydrate to the primary circuit make-up water shall be terminated 24 hours prior to the reactor plant cooling down.

#### 1.6.2 In the course of the Unit cool-down, the coolant cleanup shall be performed by filters of non-cooled coolant cleanup systems (ТС60-90) and primary circuit blow-down water treatment system (ТС) until the forced circulation is terminated.

#### 1.6.3 During the Unit shutdown with subsequent primary circuit equipment unsealing during cool-down period, the coolant degassing is performed due to operation of make-up water deaerator, water-exchange and gas blow-off. Primary circuit unsealing shall be allowed after solute hydrogen concentration decreasing up to 0.5 mg/dm3 and less.

#### 1.6.4 In "cold" condition of the Unit, boric acid concentration in the coolant shall be defined by the requirements of the neutron-physics characteristics album.

#### 1.6.5 In "refueling" and "shutdown for repair" condition of the Unit, or when performing nuclear-hazardous activities, boric acid concentration shall be within the range (16÷20) g/dm3.

#### 1.6.6 In "cold" condition of the Unit, as well as in "shutdown for repair" or "refueling" conditions at the moment of the primary circuit unsealing, the diagnostic quality indices of the coolant and water in the fuel pool and refueling pool shall be in correspondence with those specified in Table F.4.

#### Table F.4 - Diagnostic quality indices of the coolant and water in the fuel pool at "cold" condition of the Unit and "shutdown for repair" condition, fuel pool and RI inspection cavity water in " refueling" condition (as well as fuel pool water in all other conditions of the Unit).

|  |  |
| --- | --- |
| Description of indices | Reference levels |
| рН value, not less | 4.2 |
| Boric acid mass concentration, g/dm3 | 16-20 |
| Mass concentration of chloride-ion, mg/dm3, not more | 0.1 |
| Fluoride-ion mass concentration, mg/dm3, not more | 0.1 |
| Fe mass concentration, mg/dm3, not more | 0.1 |
| Total organic carbon concentration, mg/dm3, not more | 0.5 |
| Clarity, %, not less | 95\* |
| \* - Clarity shall be defined when the Unit is in "refueling" condition | |

*APPENDIX F CONTINUATION*

#### 1.7 The Unit startup from "cold" condition, after "refueling" or "shutdown for repair" conditions.

#### 1.7.1 Diagnostic quality indices of boric acid solution in TD system tanks that are used for filling the primary circuit prior to the core refueling after performing process operations related to the complete core unloading or repair, and also after primary circuit equipment deactivation, shall meet the requirements in Table F.5:

Table F.5 Diagnostic quality indices of boric acid solution in TD system tanks:

|  |  |
| --- | --- |
| Description of indices | Reference levels |
| рН value, not less | 4.2 |
| Boric acid mass concentration, g/dm3 | 16-20 |
| Mass concentration of chloride-ion, mg/dm3, not more | 0.10 |
| Clarity, %, not less | 95 |

#### 1.7.2 After coolant heat-up up to (80÷90)°С temperature, oxygen concentration shall be reduced by injecting hydrazine-hydrate to the primary circuit in the amount providing its twice or triple excess relatively oxygen concentration in the coolant.

Hydrazine-hydrate shall be injected until the oxygen concentration in the coolant is decreased up to the values specified in Table F.3.

#### 1.7.3 Increasing of temperature of primary circuit coolant over 120°С is allowed after decreasing solute oxygen mass concentration in the coolant up to 0.02 mg/dm3 and lower.

#### 1.7.4 Saturation of TC system MBF (operating and standby) anion-exchange bed with boric acid shall be performed just prior to primary circuit water-exchange or in the process of water-exchange due to its absorbing from the primary circuit coolant.

#### 1.7.5 Prior to RP approaching to MCL, ammonia and potassium hydroxide solutions shall be injected to the primary coolant from TB system to saturate MBF (operating and standby) cation-exchange bed of TC system with ammonia and potassium.

#### 1.7.6 When bringing the Unit to “hot” condition and “the reactor is at minimally-controlled level of power” condition, coolant quality norms shall be in correspondence with the requirements of Table F.3.

#### 1.8 Requirements to the quality of make-up water, distillate and borated solutions of the reactor plant safety systems.

#### 1.8.1 Requirements to the quality of make-up water.

#### 1.8.1.1 Diagnostic quality indices of the primary circuit make-up water of the TB system, and water supplied for the reactor coolant pumps sealing shall meet the requirements specified in Table F.6.

#### 1.8.1.2 When injecting distillate, boric acid solutions, potassium hydroxide or ammonia to the primary circuit without their preliminary deaeration, hydrazine-hydrate solution shall be fed from TB system to the makeup pump suction in the amount providing its twice or triple excess relatively to the oxygen concentration in these solutions or distillate.

*APPENDIX F CONTINUATION*

Table F.6 - Diagnostic quality indices of the make-up water and water supplied to the shaft seal system of the reactor coolant pumps

|  |  |
| --- | --- |
| Description of indices | Reference levels |
| рН value | 5.9 ÷ 10.3\* |
| Ammonia mass concentration, mg/dm3, not less | not less than the current one |
| Mass concentration of chloride-ion, mg/dm3, not more | 0.1 |
| Mass concentration of solute oxygen, mg/dm3, not more | 0.02\*\* |
| Sodium mass concentration, mg/dm3, not more | 1.0 |
| Silicic acid mass concentration, mg/dm3, not more | 0.5 |
| Fe mass concentration, mg/dm3, not more | 0.05 |
| Total organic carbon concentration, mg/dm3, not more | 0.5 |
| Boric acid concentration, g/dm3 | not less than the current one |
| \* - It is allowed to reduce рН value of make-up water up to value 3.8 in the periods of feeding boric acid solutions to the primary circuit. When injecting potassium and ammonia hydroxide to the primary circuit, the upper level of the make-up water pH value shall not be established.  \*\* - When injecting hydrazine-hydrate to make-up water, oxygen concentration shall not be rated.  \*\*\*- In the process of water exchange and injection of boric acid solution to the primary circuit, control level for the “boric acid concentration” index shall not be established. | |

#### 1.8.2 Requirements to the quality of distillate and borated solutions of the reactor plant safety systems.

#### 1.8.2.1 Diagnostic quality indices of the borated solution in the hydraulic accumulators of the emergency core cooling system (EСCS) of stage 1 shall correspond to the levels of values specified in Table F.7.

#### 1.8.2.2 Diagnostic quality indices of the solutions in the emergency boric acid storage tanks and hydraulic accumulators of the emergency core cooling system (EСCS) of stage 2 shall correspond to the levels of values specified in Table F.8.

1.8.2.3 Diagnostic quality indices of the solutions in the concentrated boric acid storage tanks shall correspond to the values specified in Table F.9.

1.8.2.4 Diagnostic quality indices of the solution in the alkaline solution storage tank to be injected to boron-containing water at functioning of the emergency and scheduled primary circuit cool-down system ТН, shall correspond to the values specified in Table F.10.

#### 1.8.2.5 Diagnostic quality indices of the distillate in the distillate supply system tanks shall correspond to the values specified in Table F.11.

*APPENDIX F CONTINUATION*

Table F.7 - Diagnostic quality indices of the solution in ECCS hydraulic accumulators of YT system (stage 1)

|  |  |
| --- | --- |
| Description of indices | Reference levels |
| рН value, not less | 6.5 |
| Boric acid mass concentration, g/dm3 | 16÷20 |
| Potassium mass concentration, mg/dm3 | 100÷200 |
| Mass concentration of chloride-ion, mg/dm3, not more | 0.15 |
| Note: When filling ECCS hydraulic accumulators, hydrazine-hydrate shall be injected to the solution in the amount creating hydrazine mass concentration not less than 100 mg/dm3. | |

Table F.8 - Diagnostic quality indices of the solution in the emergency boric acid storage tanks and in ECCS hydraulic accumulators of stage 2

|  |  |
| --- | --- |
| Description of indices | Reference levels |
| рН value, not less | 4.2 |
| Boric acid mass concentration, g/dm3 | 16÷20 |
| Mass concentration of chloride-ion, mg/dm3, not more | 0.10 |

Table F.9 - Diagnostic quality indices of the solution in the concentrated boric acid storage tank

|  |  |
| --- | --- |
| Description of indices | Reference levels |
| рН value, not less | 3.8 |
| Boric acid mass concentration, g/dm3 | 39.5÷44.5 |
| Mass concentration of chloride-ion, mg/dm3, not more | 0.15 |

Table F.10 - Diagnostic quality indices of the boric acid alkaline solution

|  |  |
| --- | --- |
| Description of indices | Reference levels |
| Boric acid concentration, g/dm3 | 39.5÷44.5 |
| Potassium concentration, g/dm3 | 100÷150 |
| Hydrazine concentration, g/dm3 | 10÷15 |

Table F.11 - Diagnostic quality indices of the distillate in the distillate supply system tanks

|  |  |
| --- | --- |
| Description of indices | Reference levels |
| рН value | 5.6 – 10.0 |
| Concentration of chloride-ion, mg/dm3, not more | 0.05 |
| Silicic acid concentration, mg/dm3, not more | 0.2 |
| Total organic carbon concentration, mg/dm3, not more | 0.5 |
| Boric acid concentration, g/dm3,not more | 0.015 |

*APPENDIX F CONTINUATION*

1.9 The main requirements to chemical control arrangement.

1.9.1 The chemical control system is intended to obtain the operative information on the primary circuit water chemistry condition by measuring the rated and diagnostic quality indices of the coolant, distillate, demineralized water and boric acid solutions of the reactor plant safety systems during the Unit operation.

1.9.2 Chemical control volume and periodicity shall provide for obtaining of the sufficient information, adequately reflecting current status of the primary circuit water chemistry and systems for its maintenance, as well as borated solutions of spent fuel and refueling pools.

1.9.3 Chemical control system hardware set includes automated and laboratory instrumentation, auxiliary units and computing facilities.

1.9.4 Optimization of chemical control data acquisition, processing, archiving and displaying is provided by the system application of the modern computing facilities and certified software.

1.9.5 Chemical control for the coolant, distillate, demineralized water and boric acid solutions in the safety systems and spent fuel and refueling pools shall be performed using metrologically certified procedures and instrumentation.

1.9.6 The following sampling points (TV) are envisaged to control quality of the coolant, make-up water, distillate, borated solutions of RP safety systems and to control treatment systems functioning:

- after primary circuit coolant aftercooler at the inlet to the coolant cleanup system TC;

- from the reactor vessel;

* after make-up pumps to control primary circuit make-up system TA water quality and water supplied to RCPS sealing water system;
* after high-temperature filters of non-cooled coolant cleanup system ТС60-90;

- after mixed bed of the primary circuit blow-down water treatment system TC;

- after cation-exchange filter of primary circuit blow-down water treatment system TC;

- after anion-exchange filter of primary circuit blow-down water treatment system TC;

- after system TG filters;

- aqueous medium from PRZ lower part and steam medium from PRZ upper part;

- from the tanks of system YT (stage 1 ECCS) and system TH (stage 2 ECCS);

- from TH10,20,30,40B001,002 tanks;

- from TW 10,20,3,40,В003,004 tanks;

- from TD11,12,13,14,15,16 В001 tanks;

- from blowdown deaerator TA10B003;

- from alkaline solution storage tanks of system TH10,20,30,40B004.

1.9.7 Primary coolant quality chemical control volume and periodicity during the Unit operation at all power levels, in “hot” condition and in the «reactor is at MCL» condition in the absence of deviations in quality indices are specified in Table F.12.

*APPENDIX F CONTINUATION*

In the periods of deviations, coolant quality chemical control shall be performed is at least once in a shift.

1.9.8 Primary circuit make-up system TA water quality chemical control volume and periodicity are specified in Table F.13.

1.9.9 Pressurizer media quality chemical control volume and periodicity during the unit power operation are specified in Table F.14.

1.9.10 Volume and periodicity of chemical control over coolant and fuel pool water quality in the "cold" condition of the Unit, in "shutdown for repair" condition, as well as fuel pool water and RI inspection cavity pool water quality in «refueling» condition and fuel pool water quality in all the other conditions of the Unit are specified in Table F.15.

During the Unit operation at all power levels, in “hot” condition and in the “reactor is at MCL” condition, boric acid control periodicity in the fuel pool is at least once per day. Control periodicity of other indices in Table F.15 is at least once a week.

1.9.11 Volume and periodicity of chemical control for functioning of ion-exchange filters of the primary coolant cleanup system shall be established by the chemical department of the nuclear power plant based on the requirements to coolant and make-up water quality provision as per sections 1.1 - 1.9.

1.9.12 Control over boric acid concentration in the emergency boric acid storage tanks and ECCS accumulators of stage 2, concentrated boric acid solution, alkaline solution of emergency and scheduled primary circuit cool-down system ТН, and solution in ECCS accumulators of stage 1 shall be performed continuously using the automated analyzers. If the automated boron analyzers are not available, boric acid concentration shall be determined at least twice a month for emergency boric acid storage tanks, ECCS accumulators of stage 2 and concentrated boric acid solution tanks, at least once a week for tanks of alkaline solution of emergency and scheduled primary circuit cool-down system, at least once a day for ECCS accumulators of stage 1, as well as upon request during filling-up and refilling.

Quality of solution in the emergency boric acid storage tanks TH10,20,30,40B001,002, concentrated boric acid solution tanks TW10,20,30,40B003,004, alkaline solution for the spray system of emergency and scheduled primary circuit cool-down system ТН and solution in ECCS accumulators shall be controlled by other indices specified in Tables F.7÷F.11 at least twice a month during filling-up and refilling, and upon request.

Distillate quality in the distillate supply system tanks TD14,15,16B001 shall be controlled at least twice a month, as well as during filling-up and refilling.

Table F.12 - Volume and periodicity of primary coolant quality chemical control during the Unit operation at all power levels as well as in “hot” condition and in the "reactor is at MCL of power" condition

|  |  |
| --- | --- |
| Quality indices | Minimal periodicity |
| рН value | Continuously automatically and once a day in the laboratory |
| Boric acid mass concentration | Continuously automatically and once per shift in the laboratory |
| Mass concentration of solute hydrogen | Continuously automatically and once a day in the laboratory |

*APPENDIX F CONTINUATION*

Table F.12, continued

|  |  |
| --- | --- |
| Quality indices | Minimal periodicity |
| Conductivity | Continuously automatically and once a day in the laboratory |
| Mass concentration of chloride-ion | Once per shift in the laboratory |
| Mass concentration of fluoride-ion | Twice a week in the laboratory |
| Mass concentration of solute oxygen | Continuously automatically and once a week in the laboratory;  At hydrogen concentration less than 2,2 mg/dm3 – once per shift |
| Potassium mass concentration | Once a day in the laboratory |
| Lithium mass concentration | Once a day in the laboratory |
| Sodium mass concentration | Once a day in the laboratory |
| Ammonia mass concentration | Once per shift in the laboratory |
| Sulphate-ion mass concentration | Once a week in the laboratory |
| Fe mass concentration | Once a week in the laboratory |
| Total organic carbon concentration | Once a week in the laboratory |
| Note: 1. Fluoride-ion concentration shall be controlled within 1000 hours after refueling.  2. In “hot” condition at the Unit startup, in the "reactor is at MCL of power" condition and at power operation <30%Nnom, hydrogen concentration shall not be defined.  3. In the absence of continuous automated control, the laboratory control shall be performed once in a shift, and once a day for other indices. | |

Table F.13 - Volume and periodicity of the chemical control over quality of primary circuit make-up water and water supplied to RCPS sealing water system

|  |  |
| --- | --- |
| Quality indices | Minimal periodicity |
| рН value | Continuously automatically and once per shift in the laboratory |
| Boric acid mass concentration | Continuously automatically and once per shift in the laboratory |
| Mass concentration of solute oxygen | Continuously automatically and once a day in the laboratory |
| Conductivity | Continuously automatically and once a week in the laboratory |

*APPENDIX F CONTINUATION*

Table F.13, continued

|  |  |
| --- | --- |
| Quality indices | Minimal periodicity |
| Ammonia mass concentration | Once per shift in the laboratory |
| Mass concentration of chloride-ion | Once per shift in the laboratory |
| Hydrazine mass concentration | When injecting hydrazine-hydrate |
| Natrium mass concentration | Once a day in the laboratory |
| Fe mass concentration | Once a day in the laboratory |
| Silicic acid mass concentration | Once a week in the laboratory |
| Total organic carbon concentration | Once a week in the laboratory |
| Note: 1. It is allowed to control silicic acid concentration in the distillate tanks of the distillate supply system TN.  2. In the absence of continuous automated control, the laboratory control shall be performed once in a shift, and once a day for other indices. | |

Table F.14 - Volume and periodicity of the chemical control over aqueous and steam pressurizer media

|  |  |  |
| --- | --- | --- |
|  | Minimal periodicity | |
| Quality indices | Aqueous phase from lower part | Steam phase from upper part |
| Mass concentration of solute hydrogen | - | \* |
| Mass concentration of oxygen | - | \*\* |
| Boric acid mass concentration | \*\*\* | - |
| \* - The control shall be performed at exceeding the upper limit of hydrogen concentration in the primary circuit coolant.  \*\* - The control shall be performed at deviation of the oxygen concentration in the primary circuit coolant from the range of the rated values.  \*\*\* - The control shall be performed at conducting primary circuit coolant water-exchanges with the change of boric acid concentration to more than 1 g/dm3 . | | |

*APPENDIX F CONTINUATION*

Table F.15 - Volume and periodicity of quality chemical control of coolant and fuel pool water at "cold" condition of the Unit and "shutdown for repair" condition, as well as quality chemical control of fuel pool water and reactor internals inspection cavities in “refueling” condition, and quality chemical control of fuel pool water in all the other conditions

|  |  |  |
| --- | --- | --- |
|  | Minimal periodicity | |
| Quality indices | At refueling | Without refueling |
| рН value | Once a day | Once a week |
| Boric acid mass concentration | Continuously automatically and once a day in the laboratory | Continuously automatically and once a week in the laboratory |
| Mass concentration of chloride-ion | Once a day | Once a week |
| Mass concentration of fluoride-ion | Once a day | - |
| Total organic carbon concentration | Once a day | Once a week 1 раз в неделю |
| Fe concentration |
| Clarity |
| Note: 1. When the continuous automated control of boric acid concentration cannot be performed, measurements shall be carried out once per a shift at refueling and not less than once a day without refueling. | | |

2 Norms of secondary circuit operation medium quality

Quality norms of secondary circuit medium are established as per requirements of norms “Reactor plant V-446. Secondary circuit water chemistry norms. 446 D4”.

Requirements to the secondary circuit medium quality shall be established:

- in startup period after shutdown and at the Unit power operation ≤50% Nnom;

- during pre-operational tests and power attainment;

- at the Unit power operation >50% Nnom.

At deviation of SG feed and blow-down water quality indices from the rated values, the limits to the Unit operation shall be introduced.

The requirements to water chemistry support facilities and maintenance methods are established as well as minimally required water chemistry control volume.

Water chemistry disturbance is a deviation of the rated SG feed and blow-down water quality indices from norms, which has not been eliminated within the time defined by the deviation levels and the measures for changeover to the certain levels of actions have not been taken.

2.1 Quality norms of secondary circuit medium during the Unit power operation <50% Nnom.

2.1.1 Diagnostic SG feed and blow-down water quality indices during the startup period after shutdown - “hot condition”, “reactor is at MCL” are specified in Table F.16.

*APPENDIX F CONTINUATION*

Table F.16 - Diagnostic SG make-up a blow-down water quality indices during the Unit startup period after shutdown (“hot condition”, “reactor is at MCL”)

|  |  |  |
| --- | --- | --- |
| Description of index | Feed water | Blow-down water from «salt» chamber |
| Levels of values | |
| Conductivity of H-cation-exhanged sample, µS/cm, not more | 0.5 | 4 |
| рН value, units | 8.5-9.5 | 8.0-9.5 |
| Oxygen concentration, mg/dm3, not more | 0.01 | - |
| Sodium concentration, mg/dm3, not more | - | 0.3 |
| Chloride-ion concentration, mg/dm3, not more | - | 0.1 |
| Fe concentration, mg/dm3, not more | 0.05 | - |
| Hydrazine concentration, mg/dm3, more than | 0.02 | - |
| Concentration of oils and heavy-oil products, mg/dm3, not more | 0.1 |  |

2.1.2 Quality norms of SG feed and blow-down water during the Unit power operation ≤50% Nnom are specified in Tables F.16 and F.17.

2.1.3 Levels of deviations in SG feed and blow-down water rated quality indices during the Unit power operation ≤50% Nnom are specified in Tables F.16, F.17 and in fig. F.1-a.

2.1.4 Prior to the turbine plant activation, the feed water shall be treated by hydrazine-hydrate supplying it to the suction header of the auxiliary feed water pumps.

|  |  |  |  |
| --- | --- | --- | --- |
| Table F.16 - Quality norms of SG blow-down water during the Unit power operation ≤50%Nnom | | | |
| Rated indices | | | |
| Index description | Rated values | Levels of deviations from the rated values | |
| 1st level (7 days → MCL) | 2nd level («cold» condition) |
| Conductivity of H-cation-exhanged sample, µS/cm | ≤0.3 | over 0.3 up to 1.0 | over 1.0 |
| Oxygen concentration, mg/dm3 | ≤0.01 | over 0.01 up to 0.05 | over 0.05 |
| Diagnostic indices | | | |
| Index description | | Levels of values | |
| рН value, units | | 8.8-9.2 | |
| Fe concentration, mg/dm3, not more | | 0.02 | |
| Hydrazine concentration, mg/dm3, more than | | 0.02 | |
| Copper concentration, mg/dm3, not more | | 0.002 | |
| Concentration of oils and heavy-oil products, mg/dm3, not more | | 0.1 | |

*APPENDIX F CONTINUATION*

*APPENDIX F CONTINUATION*

Table F.17 - Quality norms of SG blow-down water from the “salt” chamber during the Unit power operation ≤50%Nnom:

|  |  |  |  |
| --- | --- | --- | --- |
| Rated indices | | | |
| Index description | Rated values | Levels of deviations from the rated values | |
| 1st level (7 days → MCL) | 2nd level («cold» condition) |
| Conductivity of H-cation-exhanged sample, µS/cm | ≤4 | over 4 up to 7 | over 7 |
| Sodium concentration, mg/dm3 | ≤0.3 | over 0.3 up to 0.5 | over 0.5 |
| Chloride-ion concentration, mg/dm3 | ≤0.1 | over 0.1 up to 0.3 | over 0.3 |
| Sulphate-ion concentration, mg/dm3 | ≤0.1 | over 0.1 up to 0.3 | over 0.3 |
| Diagnostic indices | | | |
| Index description | | Levels of values | |
| рН value, units | | 8.5-9.0 | |

|  |
| --- |
|  |

Zone 1

Zone 3

Zone 3

Zone 2

*APPENDIX F CONTINUATION*

µg/kg

µg/kg

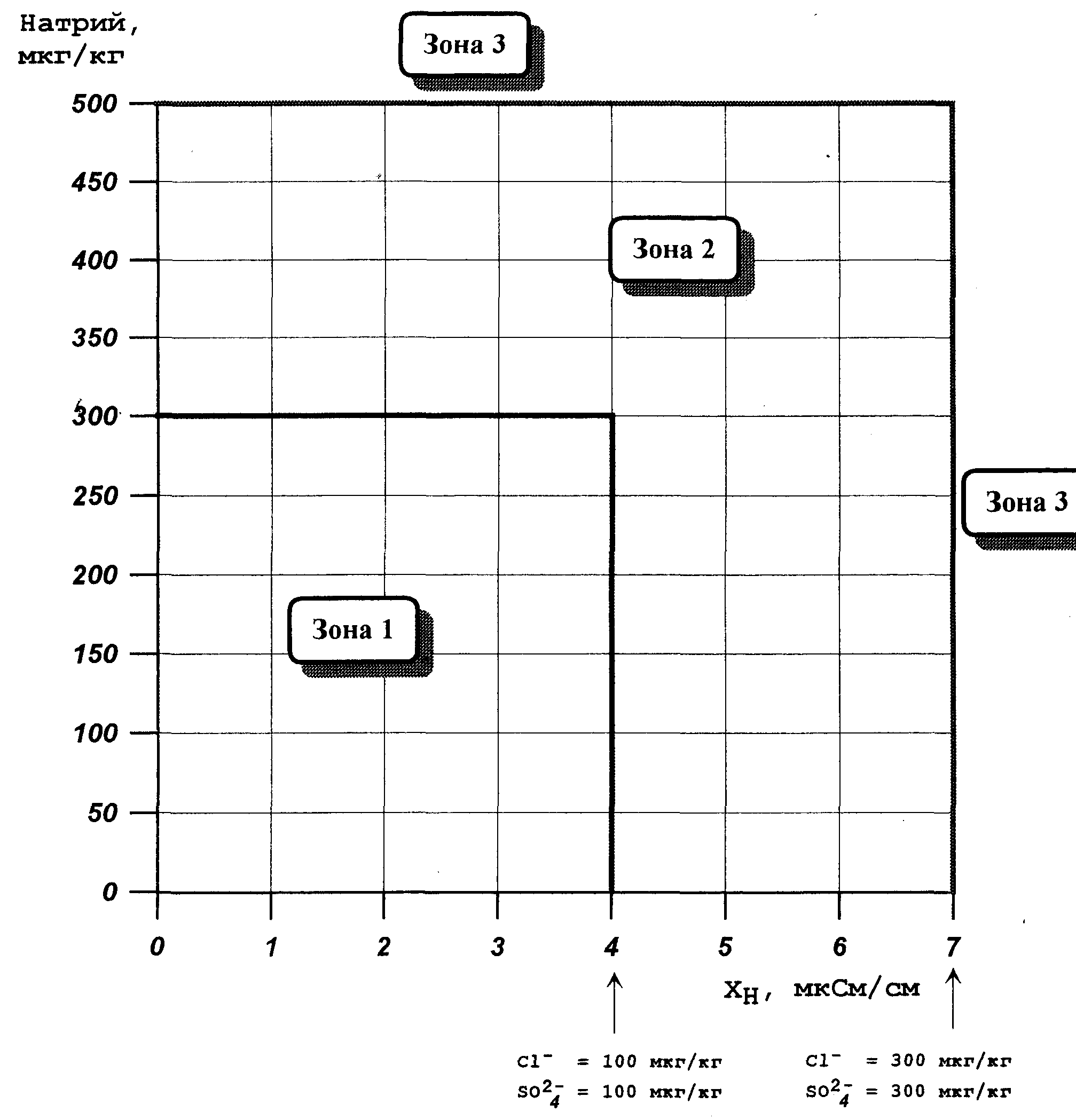
µg/kg

µg/kg

mkCm/cm

Sodium,

µg/kg



Zone 1 – area of the rated values.

Zone 2 - 1st level of deviations (7 days → MCL).

Zone 3 - 2nd level of deviations («cold» condition).

Fig. F.1-a. – Levels of deviations in the rated indices of SG blow-down water during the Unit power operation ≤50% Nnom.

#### 2.1.5 After the turbine plant activation, the operating medium shall be treated with hydrazine-hydrate within 24hr maintaining hydrazine concentration in feed water as not less than 0.5 mg/dm3.

During operating medium treatment with hydrazine-hydrate and within 24hr after it, it is allowed to increase feed water рН value up to 9.8, and blow-down water рН value – up to 9.4.

*APPENDIX F CONTINUATION*

#### 2.1.6 Hydrazine-hydrate shall be supplied to the suction headers of the second stage condensate pumps. If required, ammonia may be fed to the feed water pumps header. At short-term standbys of the Unit for the period less than 3 days, it is allowed not to treat the operating medium by hydrazine-hydrate at the consequent startup.

#### 2.1.7 After the turbine plant activation, iron content increasing in feed water up to 0.05 mg/dm3 isallowed within not more than 8hr.

#### 2.1.8 During the Unit power operation ≤10% Nnom, provided that the rated feed water quality is observed, increasing of chloride ion, sulphate-ion, sodium concentration and H-cation-exhanged sample Conductivity in SG blow-down water is allowed for the period not more than 30 days within the first level of deviations specified in Table F.17.

#### 2.2 Actions to be taken in case of deviations in the rated quality indices of operating medium during the Unit power operation ≤50% Nnom.

#### 2.2.1 The first level of actions: The permissible duration of the Unit power operation ≤50% Nnom at deviations of the rated SG feed and blow-down water quality indices within the deviation level specified in Tables F.16, F.17, and in fig. F.1-a (Zone 2) shall not exceed 7 days starting from the moment of the deviation reveal.

If it is impossible to reveal the reasons and eliminate the deviations from the rated indices within 7 days, transfer the Unit to the “reactor is at MCL of power” condition in a controlled manner.

The subsequent increasing of the Unit power up to the ≤50% Nnom is possible after elimination of the reasons for deviation and recovery of the SG feed water or blow-down water quality indices up to the rated values specified in Tables F.16, F.17.

#### 2.2.2 Second level of actions: The Unit shall be transferred to “cold” condition on a scheduled basis when the SG feed water and blow-down water quality indices reach the values of the second level of deviations as specified in Tables F.16, F.17, and in fig. F.1-a (Zone 3).

* 1. The Unit power operation >50% Nnom.

#### 2.3.1 Diagnostic quality indices of the turbine condensate and saturated steam of the steam-generators during the Unit power operation >50% Nnom are specified in Table F.18.

Table F.18 - Diagnostic quality indices of the turbine condensate and SG saturated steam during the Unit power operation >50% Nnom

|  |  |  |
| --- | --- | --- |
| Index description | Turbine condensate after the 1 stage condensate pump | Saturated steam |
| Levels of values | |
| Conductivity of H-cation-exhanged sample, µS/cm | 0,2 | 0,15 |
| Oxygen concentration, mg/dm3, not more | 30 | - |

#### 2.3.2 Norms of SG feed water and blow-down water quality during the unit power operation >50% Nnom are specified in Tables F.19 and F.20.

*APPENDIX F CONTINUATION*

#### 2.3.3 Levels of deviations of the rated SG feed water and blow-down water quality indices during the unit power operation >50% Nnom are specified in Tables F.19, F.20, and in Fig. F.2.

#### 2.3.4 At transferring from one power level of the Unit to the other one, provided that there is no deviations in feed water quality, increasing of chloride ion, sulphate-ion, sodium concentration and H-cation-exchange sample Conductivity for the first deviation level in SG blow-down water is allowed within the period not more than 8 hours.

*APPENDIX F CONTINUATION*

Table F.19 – Diagnostic quality indices of the turbine condensate and SG saturated steam during the Unit power operation >50% Nnom

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Rated indices | | | | | |
| Index description | Rated values | Levels of deviations from the rated values | | | |
| Level 1 (7 days → ≤50% Nnom) | | Level 2  (24 hr → MCL) | Level 3 (“cold” condition) |
| Conductivity of H-cation-exhanged sample, µS/cm | ≤0.15 | over 0.15 to 0.5 | | over 0.5 to 1.0 | over 1.0 |
| Oxygen concentration, mg/dm3 | ≤0.01 | over 0.01 to 0.05 | | - | over 0.05 |
| Diagnostic indices | | | | | |
| Index description | | | Levels of values | | |
| рН value, units | | | 9.0-9.2 | | |
| Fe concentration, mg/dm3, not more | | | 0.01 | | |
| Copper concentration, mg/dm3, not more | | | 0.001 | | |
| Hydrazine concentration, mg/dm3, more | | | 0.02 | | |
| Concentration of oils and heavy-oil products, mg/dm3, not more | | | 0.1 | | |

*APPENDIX F CONTINUATION*

Table F.20 - Quality norms of SG blow-down water from “salt” chamber during the Unit power operation >50% Nnom.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Rated indices | | | | | | | |
| Index description | Rated values | Areas of deviations from the rated values without decreasing the Unit power | | | Levels of deviations from the rated values | | |
| First area (15 days→ Level 1) | Second area (3 days→ Level 1) | | Level 1 (7 days → ≤50% Nnom) | Level 2 (24hr→MCL) | Level 3 (“cold” condition) |
| Conductivity of H-cation-exhanged sample, µS/cm | ≤1.5 | - | Figure F.2 | | over 1.5 to 4 | over 4 to 7 | over 7 |
| Sodium concentration, mg/dm3 | ≤0.1 | over 0.1 to 0.2 | over 0.2 to 0.3 | over 0.3 to 0.5 | over 0.5 |
| Chloride-ion concentration, mg/dm3 | ≤0.05 | - | - | | over 0.05 to 0.1 | over 0.1 to 0.3 | over 0.3 |
| Sulphate-ion concentration, mg/dm3 | ≤0.05 | - | - | | over 0.05 to 0.1 | over 0.1 to 0.3 | over 0.3 |
| Diagnostic indices | | | | | | | |
| Index description | | | | Levels of values | | | |
| рН value, units | | | | 8.5 - 9.0 | | | |
|  | | | |

Zone 6

Zone 6

Zone 5

Zone 4

Zone 3

Zone 2

Zone 1

µsm /cm

µg/kg

µg/kg

µg/kg

µg/kg

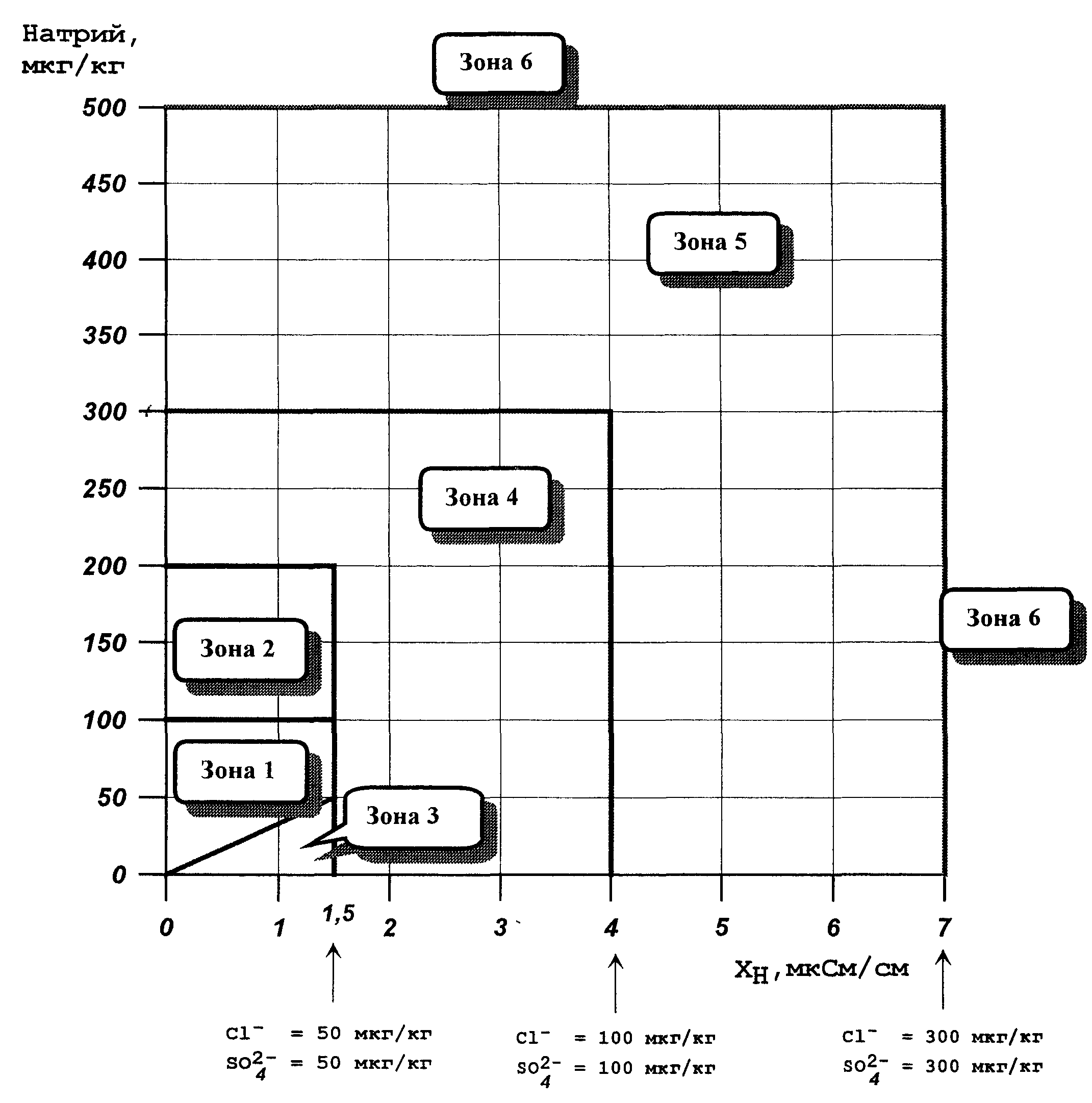
µg/kg

µg/kg

Sodium,

µg/kg

*APPENDIX F CONTINUATION*



Zone 1 –area of the rated values

Zone 2 – first area of deviations without Unit power decreasing (15 days → level 1)

Zone 3 – second area of deviations without Unit power decreasing (3 days → level 1)

Zone 4 - 1st level of deviations (7 days →≤50% Nnom)

Zone 5 - 2nd level of deviations (24 hours → MCL)

Zone 6 - 3rd level of deviations («cold» condition)

Figure F.2 - Levels of deviations in rated quality indices of the SG blow-down water at power operation of the Unit >50% Nnom.

*APPENDIX F CONTINUATION*

2.4 Actions to be taken at the rated operating medium quality indices deviation during the Unit power operation >50% Nnom.

#### 2.4.1 Areas of deviations without reducing the Unit power.

- The first area. At sodium concentration increasing in SG blow-down water within the first area specified in Table F.20 and in fig. F.2 (Zone 2), it is required to eliminate the reasons for deviations and recover the index in compliance with the rated value specified in Table F.20.

Time of continuous Unit operation in the first area of deviations shall not exceed 15 days. If it is impossible to recover the sodium concentration in compliance with the norms within the specified time – turn to the first level of actions.

- The second area. At values of the H-cation-exchanged sample Conductivity (at 25°С) and sodium concentration in the steam-generator blow-down water being in the second area of deviations (see fig. F.2 - Zone 3), it is required to search and eliminate the reasons for deviations.

If it is impossible to recover the ratio of sodium concentration and H-cation-exchanged sample Conductivity of SG blow-down water from the “salt” chamber within 3 days, to be in correspondence with the normal operation area - turn to the first level of actions.

#### 2.4.2 First level of actions: The permissible duration of the Unit power operation >50% Nnom at deviations of one or several rated SG feed water or blow-down water quality indices within the first level of deviations specified in Tables F.19, F.20 and in Fig. F.2 (Zone 4) shall not exceed 7 days starting from the moment of the deviation reveal.

#### If it is impossible to reveal the reasons and eliminate the deviations of the rated indices within 7 days – reduce the Unit power up to the value not more than 50% Nnom.

#### The consequent power increasing up to the levels higher than 50% Nnom is possible after eliminating the reasons for deviations and recovery of indices up to the rated values specified in Tables F.19, F.20.

#### 2.4.3 The second level of actions: The permissible duration of the Unit power operation at deviation of the rated indices within the second level of deviations specified in Tables F.19, F.20 and in fig. F.2 (Zone 5) shall not exceed 24 hr from the moment of the deviation reveal.

#### If it is impossible to reveal the reasons and eliminate the deviations of the rated indices within 24 hr – transfer the Unit to the “reactor is at MCL” condition on a scheduled basis.

#### The consequent Unit power increasing up to the levels higher than 50% Nnom is possible after eliminating the reasons for deviations and recovery of indices up to the rated values specified in Tables F.18, F.19.

#### 2.4.4 The third level of actions: The Unit shall be transferred to “cold” condition on a scheduled basis when SG feed water and blow down water quality indices reach the values of the third level of deviations specified in Tables F.19, F.20, and in fig. F.2 (Zone 6).

#### 2.5 The requirements to water chemistry support systems and maintaining methods.

#### 2.5.1 Demineralizing system (UA), demineralized water system (UD) and «contaminated» condensate tank of the turbine hall drainage system.

#### 2.5.1.1 Indices of the demineralized water supplied to the secondary circuit systems after demineralizing system (UA) shall correspond to the following values:

#### *APPENDIX F CONTINUATION*

- conductivity – not more than 0.3 µS/cm.

- рН value- from 5.5 to 8.0.

- summary chloride-ion concentration – not more than 0.01 mg/dm3.

- concentration of oils and heavy-oil products – not more than 0.1 mg/dm3.

#### 2.5.1.2 H-cation-exchanged water sample conductivity in the «contaminated» condensate tank of the turbine hall drainage system (diagnostic index) shall not exceed 1.5 µS/cm.

#### 2.5.1.3 Chemically demineralized water used at post-mounting flushing, for secondary circuit initial filling and SG and secondary circuit equipment hydraulic tests shall correspond to the following quality:

|  |  |
| --- | --- |
| Conductivity, µS/cm, not more than | 1.2 |
| рН value, units | 5.0-8.0 |
| Chloride-ions concentration, mg/dm3, not more than | 0.05 |
| Silicic acid concentration, mg/dm3, not more than | 0.02 |
| Concentraiton of oils and heavy-oil products, mg/dm3, not more than | 0.1 |
| Total organic carbon concentration, mg/dm3, not more | 0.2 |

2.5.1.4 Demineralized water conductivity in emergency storage tanks (diagnostic index) shall not exceed 1.2 µS/cm

#### 2.5.2 Condensation and degassing system

#### 2.5.2.1 Condensation and degassing system shall provide for oxygen concentration in the turbine condensate at first stage CEP not more than 0.03 mg/dm3.

#### 2.5.2.2 At increasing of the turbine condenser H-cation-exchanged sample conductivity at the control point prior to the turbine condensate demineralizing system UB over 0.2 µS/cm, the measures shall be taken to search and eliminate the reasons for exceeding the mentioned index.

#### 2.5.2.3 Conductivity of moisture separator separant H-cation-exchanged water sample shall not exceed 0.15 µS/cm.

#### 2.5.3 Turbine condensate demineralizing system (UB)

#### 2.5.3.1 Turbine condensate demineralizing system MBF shall operate in H+– ОН- - form.

#### Before the turbine condensate demineralizing system MBF, the regenerable cation-exchange filters in H+ - form are installed.

#### 2.5.3.2 Value of H-cation-exchanged condensate sample conductivity at the outlet of each MBF shall not exceed 0.15 µsm/cm.

#### At connecting UDP after regeneration or idling in the standby, pre-startup rinsing shall be performed up to the conductivity value at the MBF outlet not more than 0.15 µsm/cm.

#### 2.5.4 Reagent dosing system (UH)

*APPENDIX F CONTINUATION*

#### 2.5.4.1 In order to maintain rated feed water pH value in compliance with the requirements of Tables F.15 and F.19, corrective medium treatment shall be provided by dosing hydrazine-hydrate and ammonia (if necessary).

#### 2.5.4.2 Hydrazine-hydrate and ammonia shall be injected using the corrective chemical injection system at flow-rate providing for the required pH value and hydrazine and ammonia concentrations in SG feed water in all modes of the Unit operation.

#### Ammonia shall be fed to the suction header of the feed water pumps, hydrazine-hydrate - to the suction header of the second stage condensate pumps.

#### 2.5.5 Steam-generator blow-down system (RZ)

#### 2.5.5.1 To maintain SG blow-down water quality, blow-down shall be performed in order to remove soluble and insoluble impurities from SG.

#### 2.5.5.2 Continuous blow-down of each SG shall be performed from “salt” chamber of the cold end face and from blow-down lines at the lower SG vessel constituent (nipples Dnom 80) and header “reservoirs” (nipples Dnom 20).

#### 2.5.5.3 Periodically it is required to increase SG blow-down flow-rate from blow-down lines at the lower SG vessel constituent and header “reservoirs” both jointly from all lines, and by each line individually.

#### Flow-rates of continuous SG blow-down from “salt” chamber of the cold end face and from blow-down lines at the lower SG vessel constituent and header “reservoirs”, periodicity and duration of blow-down flow increasing from blow-down lines at the lower SG vessel constituent and header “reservoirs” are defined by SG Operation Manual 446.05 RE and specification on the blow-down system operation (RZ).

#### 2.5.5.4 At the Unit startup and transferring from one power level to another one, blow-down of each SG from “salt” chamber shall be maintained at the maximally possible level till reaching the rated operating medium quality indices.

#### 2.5.5.5 At deviation of the “salt” chamber blow-down water quality from the rated values within the area of 1st or 2nd level of deviations as per Tables F.17, F.20, the blow-down flow-rate from SG “salt” chamber shall be increased up to the maximally possible one.

#### 2.5.5.6 It is not allowed to use periodic blow-down to eliminate the deviations from norms by blow-down water activity.

#### 2.5.5.7 It is allowed to terminate continuous blow-down from the “salt” chamber of at least one SG due to failure of the blow-down system for the period not longer than 8hr. If it is impossible to recover the blow-down system serviceability, the Unit shall be transferred to “cold” condition in a controlled manner.

#### 2.5.6 Steam-generator blow-down demineralizing system (UZ)

#### 2.5.6.1 After blow-down extender, all steam-generator blow-down water flow shall pass demineralizing at UZ facility.

#### 2.5.6.2 Quality of demineralized SG blow-down water returnable to the secondary circuit shall provide operating medium quality as per requirements of sections 2.1-2.4. At the same time, conductivity value of demineralized SG blow-down water at UZ system outlet (diagnostic index) shall not exceed 0.3 µsm/cm.

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#### 2.5.7 Operating medium treatment with hydrazine-hydrate prior to the Unit shutdown

#### for condensate-feeding path preservation for the period of the Unit shutdown

#### 2.5.7.1 At the short-term Unit shutdowns for the period less than 3 days, it is allowed not to treat the operating medium with hydrazine-hydrate for condensate-feeding path preservation.

#### 2.5.7.2 Prior to the Unit shutdown for the period from 3 days up to 3 months, to preserve CFP, the operating medium shall be treated by hydrazine-hydrate within 24-48 hours with maintaining hydrazine concentration in feed water not less than 0.5 mg/dm3.

#### 2.5.7.3 It is allowed to trip the cation-exchange filters and the turbine condensate demineralizing system (UB) MAFs from the moment of starting the increased hydrazine-hydrate dosing.

#### During this period, the steam-generators shall be blown-down by turns with the maximally possible flow-rate.

#### 2.5.7.4 During the period of the operating medium treatment with hydrazine-hydrate, it is allowed to increase feed water pH value up to 9.8, and blow-down water pH value – up to 9.4.

#### 2.5.7.5 After treatment of the operating medium with hydrazine-hydrate, it is allowed to shutdown the equipment and pipelines filled with feed water.

#### To perform hydraulic tests, the equipment and pipelines shall be filled with demineralized water of quality as per item 2.5.1.3 plus hydrazine-hydrate up to the hydrazine concentration of 20-30 mg/dm3, and ammonia - up to the pH value of 9.0-10.5.

#### After hydraulic testing, it is allowed not to drain the equipment and pipelines.

#### 2.5.8 Chemical cleanup of the steam-generators.

#### 2.5.8.1 Chemical cleanup of SG shall be performed in order to remove sediments and sludge from the heat-exchanging surfaces, SG vessel and from the blow-down lines.

#### 2.5.8.2 Chemical cleanup of SG are performed during scheduled RP cool-down. Periodicity of each SG flushing is determined based on the results of corrosion examination of SG internal surfaces formalized by respective test sheets, once every 4 years as minimum.

#### 2.5.9 Secondary circuit WC control volume and periodicity at the Unit operation at power levels are specified in Table F21.

*APPENDIX F CONTINUATION*

# Table F.21 – Scope and periodicity of the secondary circuit water chemistry control at the Unit operation at power levels

|  |  |  |
| --- | --- | --- |
| Sampling place | Description of indices | Periodicity |
| Condensate downstream each turbine section | Conductivity of H-cation-exchange sample | Automatically 1) |
| Sodium concentration | Automatically 1) |
| Condensate downstream first stage CP | Conductivity of H-cation-exchange sample | Automatically and once a day in laboratory |
| Oxygen concentration | Automatically 1) |
| Sodium concentration | Automatically and once a day in laboratory |
| Condensate downstream each cation-exchange filter of turbine condensate demineralizing system (UB) | Fe concentration | Once a day in laboratory |
| pH value | Once a day in laboratory |
| Condensate downstream each MBF of turbine condensate demineralizing system (UB) | Sodium concentration | Automatically 1) |
| Conductivity | Automatically 1) |
| Condensate downstream first stage CP | Ammonia concentration | Once a shift in laboratory |
| Conductivity of H-cation-exchange sample | Automatically 1) |
| Feed water downstream deaerator | Oxygen concentration | Automatically 1) |
| Feed water downstream HPH | Conductivity of H-cation-exchange sample | Automatically 1) |
| pH value | Automatically 1) |
| Fe concentration | Once a week in laboratory |
| Copper concentration | Once a week in laboratory |
|  |  |  |
|  | *APPENDIX F CONTINUATION* |  |
| Table F.21, continued |  |  |
| Sampling place | Description of indices | Periodicity |
| Feed water downstream HPH | Hydrazine concentration | Once a shift in laboratory |
| Ammonia concentration | Once a shift in laboratory |
| Concentration of oils and heavy oil products | Twice a week in laboratory |
| Each SG blow-down water from "salt" section | Chloride-ion concentration | Automatically 1) |
| Sodium concentration | Automatically 1) |
| Sulphate-ion concentration | Automatically 1) |
| Conductivity of H-cation-exchange sample | Automatically 1) |
| pH value | Automatically 1) |
| Each SG blow-down water from united blow-down line | Sodium concentration | Once a day in laboratory |
| Conductivity of H-cation-exchange sample | Once a day in laboratory |
| Each SG saturated steam | Conductivity of H-cation-exchange sample | Automatically and once a day in laboratory |
| Water at blow-down water treatment system outlet (UZ) | Conductivity | Automatically 1) |
| pH value | Once a shift in laboratory |
| Water of “contaminated” condensate tank of the turbine hall drainage system | Conductivity of H-cation-exchange sample | Automatically 1) |
| Make-up water after demineralizing system MBF | Conductivity | Automatically and once a day in laboratory |
| pH value | Automatically and once a day in laboratory |
|  |  |  |
|  | *APPENDIX F CONTINUATION* |  |
| Table F.21, continued |  |  |
| Sampling place | Description of indices | Periodicity |
| Make-up water after demineralizing system MBF | Chloride-ion concentration | Automatically and once a day in laboratory |
| Concentration of oils and heavy oil products | Once a week in laboratory |
| Emergency demineralized water storage tank | Conductivity | Once a week in laboratory |
| Water of demineralized water storage tank (UD) | Conductivity | once a day in laboratory |
| pH value | once a day in laboratory |
| Chloride-ion concentration | once a day in laboratory |
| Silicic acid concentration | Once a week in laboratory |
| Concentration of oils and heavy oil products | Once a week in laboratory |
| Moisture separator separant | Conductivity of H-cation-exchange sample | Automatically 1) |
| 1) At trip of automatic control devices, analysis shall be performed at least once in a shift | | |

# APPENDIX G

Natural circulation availability control

#### 1 The natural circulation (NC) shall be controlled by the following features:

1) as per the temperature at FA outlet, the margin up to the coolant boiling up is more than 15 °C;

2) SG pressure is stable or decreasing;

3) temperature in the hot legs is stable or decreasing;

4) temperature at FA outlet is stable or decreasing;

1. temperature in the cold leg id close to saturation temperature in SG;
2. availability of temperature differential at MCP loop.

#### 2 If the natural circulation is not available, establish it by short-term increasing of steam relief from SG.

#### 3 At availability of NC, by maintaining SG level and steam relief amount control, do not allow the following:

1) temperature increasing at the outlet from the most stressed FA over 330 °С;

2) coolant heat-up at any loop over 55 °C;

3) temperature differential increasing in the hot legs of loops and under the reactor top head over 50 °С;

4) cool-down rate increasing over 15 °С/hr.

# APPENDIX H

Pressure and temperature limits (Р/Т) in reactor coolant system



Figure Н.1 − Permissible pressure for the modes of heating and cooldown

# APPENDIX J

Stages of ICIS “degradation”

1 ICIS degradation.

Degradation is the system condition, which is characterized by availability of failures in operation or failure of individual elements and units, effecting to the system functioning in different degree.

1.1 Failure of instrumentation and computing equipment.

At failure of two ICIS CC (no any possibility to use CC computing resources to monitor RP parameters), ICIS processor capabilities are limited by ICIS SHWC-LL.

Complete SHWC-LL failure cause loss of information on current neutron-physics and thermal-and hydraulic characteristics of the core, it eliminates possibility of the core protection by local parameters, keeping current events archive.

Failure of individual SHWC-LL measuring channels elements cause degradation of the system informational capabilities and shall be reviewed below as reducing of ICIS sensors signals number. ICDS distribution by protection channels is listed in Table J.1.

1.2 Failure of the in-core detectors

Degradation of in-core detectors design set (depending on the number and location of the faulty sensors) can cause reducing or non-fulfillment of field distribution control function in the core area, where no serviceable detectors are available.

1.3 Stages of ICIS “degradation”

1.3.1 First stage of «degradation» is when by reason of insulation resistance decreasing or SPND (P) failure, or availability of significant noise level at the cable routes, or failure of any SHWC-LL equipment level, some measuring channels are not capable to perform their measurement functions at the defined error, or by the reason of SPND failure, uncontrolled volume is not more than 13 FA provided that "local uncontrolled sections"[[1]](#footnote-2)\* are available.

1.3.2. The second stage of «degradation» is when by the reasons described in item 1.3.1, uncontrolled volume is not more than 13 FA provided that at least one "local uncontrolled section".

1.3.3 The third stage of «degradation» starts, when uncontrolled core volume is from 14 to 82 FA.

1.3.4 The fourth stage of «degradation» starts, when SPND-uncontrolled part of the core is from 82 and more FA.

*APPENDIX J CONTINUATION*

2 allowed reactor power at different stage of icis sensors degradation.

2.1 Reaching the nominal power after refueling procedure or shutdown with the reactor unsealing is allowed only at availability of the system providing effective core control and availability of at least 90% of serviceable ICDS provided that the second stage of degradation by SPND is not available.

2.2 At failure of the in-core detectors it is required:

upon reaching the second “degradation” stage, it is required to reduce power up to 90% of the nominal one;

upon reaching the second “degradation” stage and simultaneous occurrence of any transient mode features, it is required to reduce power up to 85% of the nominal one;

upon reaching the third “degradation” stage, it is required to reduce power up to 80% of the nominal one;

upon reaching the third “degradation” stage and simultaneous occurrence of any transient mode features, it is required to reduce power up to 75% of the nominal one;

upon reaching the fourth “degradation” stage, the reactor shall be changed over to «hot» shutdown mode.

#### 2.3 At SHWC-P failure for the time more than two hours, it is required to evaluate «degradation» stage, and if required, perform actions listed in item 2.2.

*APPENDIX J CONTINUATION*

correspondence of fa numbers and numbers of their adjacent (nearest) 6 controlling icds

Table J.1

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| FA No. | 1 channel | 2 channel | 3 channel | 4 channel | 5 channel | 6 channel |
| 1 | 10(2) | 16(4) | 30(4) | 12(4) | 2(2) | 18(2) |
| 2 | 10(2) | 16(5) | 30(4) | 12(4) | 2(0) | 5(3) |
| 3 | 10(1) | 16(5) | 14(5) | 12(2) | 2(2) | 5(2) |
| 4 | 10(3) | 47(5) | 14(4) | 12(2) | 2(3) | 5(1) |
| 5 | 10(3) | 47(5) | 14(3) | 12(1) | 2(4) | 5(0) |
| 6 | 34(3) | 47(5) | 14(2) | 12(3) | 2(4) | 5(1) |
| 7 | 10(3) | 16(1) | 30(4) | 12(5) | 2(3) | 18(2) |
| 8 | 10(3) | 16(2) | 30(3) | 12(5) | 2(2) | 18(1) |
| 9 | 10(1) | 16(4) | 30(2) | 12(4) | 2(1) | 18(1) |
| 10 | 10(0) | 16(4) | 30(3) | 12(3) | 2(1) | 18(2) |
| 11 | 10(1) | 31(5) | 30(2) | 12(1) | 2(2) | 5(2) |
| 12 | 10(2) | 31(5) | 14(2) | 12(0) | 2(3) | 5(1) |
| 13 | 34(2) | 47(4) | 14(1) | 12(1) | 44(4) | 5(1) |
| 14 | 34(2) | 47(3) | 14(0) | 12(2) | 44(4) | 15(1) |
| 15 | 34(2) | 47(3) | 14(1) | 12(3) | 75(5) | 15(0) |
| 16 | 39(2) | 16(0) | 50(3) | 52(5) | 2(4) | 18(2) |
| 17 | 39(2) | 16(1) | 50(3) | 52(5) | 2(3) | 18(1) |
| 18 | 39(2) | 16(2) | 30(2) | 12(4) | 2(2) | 18(0) |
| 19 | 10(1) | 16(5) | 30(1) | 12(4) | 54(3) | 18(1) |
| 20 | 10(1) | 16(4) | 30(1) | 12(2) | 2(2) | 18(2) |
| 21 | 10(2) | 31(5) | 30(2) | 12(1) | 44(2) | 33(2) |
| 22 | 34(2) | 47(4) | 14(2) | 12(1) | 44(2) | 33(1) |
| 23 | 34(1) | 47(3) | 14(1) | 12(2) | 44(2) | 33(1) |
| 24 | 34(1) | 47(2) | 14(1) | 12(3) | 44(3) | 15(1) |
| 25 | 34(2) | 47(2) | 14(3) | 12(4) | 75(4) | 15(1) |
| 26 | 39(2) | 16(1) | 50(2) | 52(5) | 79(5) | 18(3) |
| 27 | 39(1) | 16(1) | 50(2) | 52(5) | 54(4) | 18(2) |
| 28 | 39(1) | 16(2) | 30(2) | 52(5) | 54(3) | 18(1) |
| 29 | 39(2) | 16(4) | 30(1) | 52(5) | 54(2) | 18(1) |
| 30 | 39(3) | 31(5) | 30(0) | 12(3) | 54(2) | 18(2) |
| 31 | 10(5) | 31(0) | 30(5) | 52(0) | 112(0) | 106(0) |
| 32 | 34(2) | 31(5) | 30(2) | 12(2) | 44(1) | 33(1) |
| 33 | 34(1) | 47(4) | 14(2) | 12(2) | 44(1) | 33(0) |

| *APPENDIX J CONTINUATION* | | | | | | |
| --- | --- | --- | --- | --- | --- | --- |
| Table J.1, continued | | | |  |  |  |
| FA No. | 1 channel | 2 channel | 3 channel | 4 channel | 5 channel | 6 channel |
| 34 | 34(0) | 47(2) | 14(2) | 12(3) | 44(2) | 33(1) |
| 35 | 34(1) | 47(1) | 59(2) | 71(3) | 44(4) | 15(2) |
| 36 | 34(2) | 47(1) | 59(2) | 71(4) | 75(4) | 15(2) |
| 37 | 39(2) | 16(2) | 50(1) | 52(5) | 79(5) | 18(4) |
| 38 | 39(1) | 16(2) | 50(1) | 52(5) | 79(4) | 18(3) |
| 39 | 39(0) | 16(4) | 50(2) | 52(5) | 54(4) | 18(2) |
| 40 | 39(1) | 16(3) | 30(2) | 52(5) | 54(2) | 18(2) |
| 41 | 39(2) | 93(4) | 30(1) | 12(4) | 54(1) | 18(2) |
| 42 | 39(3) | 31(5) | 30(1) | 71(4) | 54(1) | 70(3) |
| 43 | 68(2) | 97(4) | 30(2) | 71(3) | 44(1) | 33(2) |
| 44 | 34(2) | 47(3) | 59(3) | 71(2) | 44(0) | 33(1) |
| 45 | 34(1) | 97(4) | 59(2) | 71(2) | 44(1) | 33(1) |
| 46 | 34(1) | 47(1) | 59(1) | 71(2) | 44(2) | 33(2) |
| 47 | 34(2) | 47(0) | 59(1) | 71(3) | 44(3) | 15(3) |
| 48 | 34(3) | 47(1) | 59(2) | 71(4) | 75(2) | 15(3) |
| 49 | 90(3) | 16(3) | 50(1) | 94(5) | 79(5) | 78(5) |
| 50 | 39(2) | 76(2) | 50(0) | 94(5) | 79(4) | 78(3) |
| 51 | 39(1) | 16(3) | 50(1) | 94(4) | 79(3) | 78(3) |
| 52 | 39(5) | 31(0) | 50(5) | 52(0) | 112(0) | 106(0) |
| 53 | 39(2) | 93(3) | 30(2) | 94(3) | 54(1) | 18(3) |
| 54 | 68(1) | 93(3) | 30(2) | 94(3) | 54(0) | 70(4) |
| 55 | 68(1) | 97(4) | 30(2) | 94(3) | 54(1) | 70(2) |
| 56 | 68(2) | 97(3) | 30(3) | 71(2) | 54(2) | 70(1) |
| 57 | 34(2) | 97(3) | 59(2) | 71(1) | 44(1) | 70(1) |
| 58 | 34(5) | 31(0) | 59(5) | 52(0) | 112(0) | 106(0) |
| 59 | 34(2) | 47(1) | 59(0) | 71(2) | 44(3) | 33(3) |
| 60 | 34(3) | 47(1) | 59(1) | 71(3) | 75(2) | 15(4) |
| 61 | 101(3) | 47(2) | 59(2) | 114(5) | 75(1) | 15(4) |
| 62 | 90(3) | 76(1) | 50(2) | 52(5) | 79(5) | 78(4) |
| 63 | 90(4) | 76(1) | 50(1) | 118(4) | 79(4) | 78(3) |
| 64 | 39(2) | 76(2) | 50(1) | 94(4) | 79(2) | 78(1) |
| 65 | 39(2) | 93(2) | 50(2) | 94(3) | 79(1) | 78(1) |
| 66 | 68(2) | 93(2) | 50(3) | 94(2) | 79(1) | 78(2) |
| 67 | 68(1) | 93(2) | 109(4) | 94(2) | 54(1) | 70(3) |
| 68 | 68(0) | 93(3) | 109(4) | 94(2) | 54(1) | 70(2) |
| 69 | 68(1) | 97(2) | 109(3) | 71(2) | 54(3) | 70(1) |
| 70 | 68(2) | 97(2) | 109(3) | 71(1) | 44(2) | 70(0) |
| 71 | 34(3) | 97(2) | 59(2) | 71(0) | 44(2) | 70(1) |
| 72 | 34(3) | 47(2) | 59(1) | 71(1) | 44(4) | 70(2) |
| 73 | 101(2) | 47(2) | 59(1) | 71(2) | 75(2) | 70(3) |
| 74 | 101(2) | 47(2) | 59(2) | 114(4) | 75(1) | 15(5) |
| 75 | 101(2) | 47(3) | 59(4) | 114(4) | 75(0) | 15(5) |
| 76 | 90(1) | 76(0) | 50(2) | 118(4) | 79(3) | 78(2) |
| 77 | 90(1) | 76(1) | 50(2) | 118(3) | 79(2) | 78(1) |
| 78 | 90(2) | 93(2) | 50(2) | 118(3) | 79(1) | 78(0) |
| 79 | 68(3) | 93(1) | 50(3) | 94(2) | 79(0) | 78(1) |
| 80 | 68(2) | 93(1) | 109(3) | 94(1) | 79(1) | 78(2) |
| 81 | 68(1) | 93(2) | 109(2) | 94(1) | 54(2) | 70(3) |
| 82 | 68(1) | 97(2) | 109(2) | 94(2) | 54(2) | 70(2) |
| 83 | 68(2) | 97(1) | 109(2) | 71(2) | 54(3) | 70(1) |
| 84 | 123(3) | 97(1) | 99(2) | 71(1) | 54(4) | 70(1) |
| 85 | 123(3) | 97(2) | 99(1) | 71(1) | 44(3) | 70(2) |
| 86 | 101(3) | 97(3) | 99(1) | 71(2) | 44(4) | 70(3) |
| 87 | 101(1) | 47(3) | 99(2) | 114(2) | 75(3) | 136(4) |
| 88 | 101(3) | 127(3) | 99(3) | 114(2) | 75(1) | 70(5) |
| 89 | 90(1) | 76(1) | 117(3) | 118(4) | 139(4) | 78(3) |
| 90 | 90(0) | 76(1) | 117(2) | 118(3) | 79(3) | 78(2) |
| 91 | 90(1) | 76(2) | 117(2) | 118(2) | 79(2) | 78(1) |
| 92 | 90(2) | 93(1) | 117(2) | 118(2) | 79(1) | 78(1) |
| 93 | 90(3) | 93(0) | 109(4) | 94(1) | 79(1) | 78(2) |
| 94 | 68(2) | 93(1) | 109(5) | 94(0) | 79(2) | 78(5) |
| 95 | 68(2) | 93(2) | 109(1) | 94(1) | 54(3) | 70(3) |
| 96 | 68(2) | 97(1) | 109(1) | 94(2) | 54(3) | 70(2) |
| 97 | 68(3) | 97(0) | 109(2) | 71(2) | 112(5) | 70(5) |
| 98 | 123(2) | 97(1) | 99(1) | 71(2) | 44(4) | 70(2) |
| 99 | 101(2) | 97(2) | 99(0) | 114(2) | 75(5) | 70(3) |
| 100 | 101(1) | 97(3) | 99(1) | 114(1) | 112(5) | 136(5) |
| 101 | 101(0) | 127(2) | 99(2) | 114(1) | 75(2) | 136(4) |
| 102 | 101(1) | 127(2) | 99(3) | 114(2) | 75(2) | 136(5) |
| 103 | 90(1) | 76(2) | 117(2) | 118(3) | 139(3) | 78(3) |
| 104 | 90(1) | 76(2) | 117(1) | 118(2) | 139(3) | 78(2) |
| 105 | 90(2) | 93(2) | 117(1) | 118(1) | 79(2) | 78(2) |
| 106 | 132(5) | 31(0) | 117(5) | 133(0) | 112(0) | 106(0) |
| 107 | 132(2) | 93(1) | 109(2) | 94(1) | 131(2) | 78(3) |
| 108 | 132(2) | 93(2) | 109(1) | 94(1) | 131(2) | 78(4) |
| 109 | 123(2) | 97(2) | 109(0) | 94(2) | 131(3) | 70(3) |
| 110 | 123(1) | 97(1) | 109(1) | 94(3) | 145(3) | 70(3) |
| 111 | 123(1) | 97(1) | 109(2) | 71(3) | 145(3) | 136(2) |
| 112 | 123(5) | 31(0) | 99(5) | 133(0) | 112(0) | 106(0) |
| 113 | 101(3) | 127(2) | 99(1) | 114(1) | 145(4) | 136(3) |
| 114 | 101(2) | 127(1) | 99(2) | 114(0) | 75(3) | 136(5) |
| 115 | 101(1) | 127(1) | 99(4) | 114(1) | 75(5) | 136(4) |
| 116 | 90(2) | 76(3) | 117(1) | 118(2) | 139(2) | 78(3) |
| 117 | 90(2) | 76(3) | 117(0) | 118(1) | 139(2) | 78(3) |
| 118 | 90(3) | 93(2) | 117(1) | 118(0) | 131(2) | 78(3) |
| 119 | 132(2) | 93(2) | 117(2) | 118(1) | 131(1) | 106(5) |
| 120 | 132(1) | 93(2) | 109(2) | 94(2) | 131(1) | 106(5) |
| 121 | 132(1) | 93(3) | 109(1) | 94(2) | 131(2) | 153(3) |
| 122 | 123(1) | 97(2) | 109(1) | 94(3) | 145(2) | 136(3) |
| 123 | 123(0) | 97(2) | 109(2) | 148(4) | 145(2) | 136(2) |
| 124 | 123(1) | 97(2) | 147(2) | 148(3) | 145(2) | 136(1) |
| 125 | 123(2) | 97(3) | 147(2) | 114(2) | 145(3) | 136(1) |
| 126 | 101(2) | 127(1) | 147(2) | 114(1) | 145(4) | 136(2) |
| 127 | 101(2) | 127(0) | 147(3) | 114(1) | 75(4) | 136(4) |
| 128 | 90(4) | 150(3) | 117(1) | 118(2) | 139(1) | 106(5) |
| 129 | 90(3) | 150(2) | 117(1) | 118(1) | 139(1) | 78(4) |
| 130 | 132(2) | 150(2) | 117(2) | 118(1) | 131(1) | 153(4) |
| 131 | 132(1) | 150(2) | 117(3) | 141(1) | 131(0) | 106(5) |
| 132 | 132(0) | 150(3) | 109(2) | 141(2) | 131(1) | 153(2) |
| 133 | 132(5) | 31(0) | 109(5) | 133(0) | 112(0) | 106(0) |
| 134 | 123(1) | 97(3) | 109(2) | 141(4) | 145(1) | 136(2) |
| 135 | 123(1) | 97(3) | 147(2) | 148(3) | 145(1) | 136(1) |
| 136 | 123(2) | 97(3) | 147(1) | 148(2) | 145(2) | 136(0) |
| 137 | 123(4) | 127(2) | 147(1) | 148(1) | 145(3) | 136(1) |
| 138 | 101(3) | 127(1) | 147(2) | 148(1) | 145(4) | 136(2) |
| 139 | 158(4) | 150(2) | 117(2) | 141(2) | 139(0) | 153(5) |
| 140 | 158(3) | 150(1) | 117(2) | 141(1) | 139(1) | 153(4) |
| 141 | 132(2) | 150(1) | 117(3) | 141(0) | 131(1) | 153(3) |
| 142 | 132(1) | 150(2) | 160(2) | 141(1) | 131(1) | 153(2) |
| 143 | 132(1) | 150(3) | 160(2) | 141(2) | 131(2) | 153(1) |
| 144 | 132(2) | 163(3) | 160(2) | 141(3) | 145(1) | 153(1) |
| 145 | 123(2) | 163(3) | 147(2) | 148(3) | 145(0) | 136(2) |
| 146 | 123(2) | 163(2) | 147(1) | 148(2) | 145(1) | 136(1) |
| 147 | 123(3) | 163(2) | 147(0) | 148(1) | 145(2) | 136(1) |
| 148 | 123(4) | 127(2) | 147(1) | 148(0) | 145(3) | 136(2) |
| 149 | 158(2) | 150(1) | 117(3) | 141(2) | 139(1) | 153(4) |
| 150 | 158(1) | 150(0) | 160(5) | 141(1) | 139(2) | 153(5) |
| 151 | 158(1) | 150(1) | 160(2) | 141(1) | 131(2) | 153(2) |
| 152 | 158(2) | 150(3) | 160(1) | 141(2) | 131(3) | 153(1) |
| 153 | 132(2) | 163(3) | 160(1) | 141(3) | 145(2) | 153(0) |
| 154 | 132(2) | 163(2) | 160(2) | 148(4) | 145(1) | 153(1) |
| 155 | 123(3) | 163(1) | 147(2) | 148(3) | 145(1) | 153(2) |
| 156 | 123(3) | 163(2) | 147(2) | 148(2) | 145(3) | 136(2) |
| 157 | 123(3) | 163(2) | 147(2) | 148(1) | 145(5) | 136(2) |
| 158 | 158(0) | 150(1) | 160(2) | 141(3) | 139(4) | 153(4) |
| 159 | 158(1) | 150(2) | 160(1) | 141(2) | 139(4) | 153(2) |
| 160 | 158(2) | 150(3) | 160(0) | 141(3) | 145(3) | 153(1) |
| 161 | 158(3) | 163(2) | 160(1) | 148(5) | 145(2) | 153(1) |
| 162 | 158(4) | 163(1) | 160(2) | 148(4) | 145(2) | 153(2) |
| 163 | 158(5) | 163(0) | 147(3) | 148(4) | 145(2) | 136(4) |

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3 MCDS functioning at failures.

At failure of one SHWC-P set, ICIS provides shaping the core protection signals by in-core local parameters using the second SHWC-P set. As far as both SHWC-P sets are galvanic-decoupled and located in different rooms, failure of one SHWC-P set does not effect to serviceability of the other SHWC-P set, however, at the same time, the error of design parameters determination in ICIS CC increases, including the factors required for SHWC-P re-calibration. At failure of one channel in SHWC-P set, protection signals shaping is also provided using one set SHWC-P channels remained in operation. The defect shall be eliminated within not more than 8 hr.

A failure is the event consisting in the protection signal non-generation, at availability of anomalies in the form of local overheating, or false generation at unavailability of such anomalies, or failure in protection shaping circuits revealed by self-diagnostics. At SHWC-P failure (which does not allow to generate protection signal), protective signal shall be shaped, which shall be sent to the relevant ESFIP channel and accompanied by the failure signal sent to process signalization, as well as to TLSU.

From viewpoint of protection signals shaping, simultaneous failure (without loosing local parameters calculation accuracy in SHWC-P, to which signals from serviceable detectors are sent) of the following below mentioned ICIS detectors is allowed:

up to two coolant temperature control sensors at each of the primary circuit circulation loops cold legs (not more than one sensor per each SHWC-P set);

up to two pressure gages at the core top (not more than one gage per each SHWC-P set);

up to two pressure differential detectors at each RCPS (not more than one detector per each SHWC-P set);

up to two power frequency detectors at each RCPS (not more than one detector per each SHWC-P set;

up to two power detectors at each RCPS (not more than one detector per each SHWC-P set);

up to two RCPS status (on-off) detectors (not more than one detector per each SHWC-P set).

Information on detectors failure is sent to TLSU.

Failures of the enumerated detectors (except for temperature control sensor and RCPS power frequency detector) shall be eliminated within 8 hours. At these failures, protection signals shall not be shaped in relevant SHWC-P channels. Failures of temperature sensors, as well as failures of RCPS power frequency detector shall be eliminated within next preventive maintenance.

ICIS degradation related to in-core instrumentation function implementation, including detectors degradation is described in item 2 of this specification.

*APPENDIX J CONTINUATION*

In case of one SHWC-IC cabinet failure, the second cabinet shall provide the system functioning, as far as the signals received at SHWC-IC shall be multiplied in the terminal cabinet. At failure of the terminal cabinet or both SHWC-IC cabinets, SHWC-IC functions are not performed. In this case, reactor power and associated values determination accuracy shall be decreasing. Reactor power determination accuracy shall also be decreasing in case of failure of the detectors, signals from which are received in SHWC-IC and involved in this power calculation. The defect shall be eliminated within not more than eight hours, otherwise, RP power shall be reduced up to 98 % of the nominal one.

At failure of one ICIS ULCC or one of ICIS redundant network facilities, the other CC or the other network facility shall provide full system functioning. At the same time, the Unit operation at the nominal power till the defect elimination is allowed. At both ICIS ULCC of ICIS redundant network facilities failure, operation at power level 100% Nnom is allowed for not more than two hours, at transient mode occurrence (by data from the other Unit systems), it is required to reduce power up to 90 % of the nominal one. If serviceability is not recovered within two hours, operation at power level 90% of the nominal is allowed till the defect elimination, but not more than 16 hours provided that the processes are steady.

At CAS (and/or AWS RM from TLSU set) failure related to «ICIS service functions» implementation, the relevant functions shall not be performed until the defect elimination. The defect shall be eliminated within not more than 72 hours, otherwise, protection function by in-core local parameters shall be withdrawn from operation. During pilot operation of protection function by in-core local parameters, at CAS failure for the time not more than 72 hours, no any limits shall be applied to RP operation. Upon completing pilot operation of protection function by in-core local parameters, limits for RP operation at CAS failure for the time more than 72 hours shall be determined by its results.

At CS-LL failure, MCDS shall function in full volume, except for SHWC-LL functioning control. Permissible time for CS-LL failure is not more than 720 hours.

At any SHWC-ICND cabinet failure, the remained SHWC-ICND cabinets shall perform their functions within received noise (variable) SPND composing signals. Respectively, the core local bulk boiling control shall be performed in CAS (ICND ASW) only by received SPND signals. At failure of both ICIS switchboards or both ICIS ULCC, the core local bulk boiling control function shall not be performed.

At failure of one group of the detectors transmitting the signal to one of SHWC-LMS (SHWC-ALMS or SHWC-LMS-H) and controlling coolant leakage occurrence at one of RP sections, the control is performed by the remained detectors with accuracy decreasing of value determination and leakage location detection using this SHWC-LMS. At failure of the only detector transmitting the signal to one SHWC-LMS (SHWC-ALMS or SHWC-LMS-H) and controlling coolant leakage occurrence at one of RP sections, the control shall be performed using the sensor (sensors) transmitting signals to the other SHWC-LMS. At failure of one SHWC-LMS (SHWC-ALMS or SHWC-LMS-H), coolant leakage occurrence control shall be provided using the other SHWC-LMS.

At failure of all LMS sensors controlling one of RP sections, or failures of both SHWC-LMS, coolant leakage control function shall not be performed. The time for the defect elimination is not more than 72 hours.

# APPENDIX K

APCS operation schedule

Abbreviations accepted in Appendix K:

EP - executive part

DAPD – data accumulation and processing device

LP - logical part

MC - measuring channel

MA - maintenance activities

PT - primary transducer

PI - protections and interlocks

OM - operation manual

OD - operational documentation

1 Introduction

1.1 This Appendix defines types, periodicity, contents and methods of APCS maintenance including protections and interlocks (PI) in order to maintain the system design characteristics and parameters.

1.2 The safe operation limits and conditions are considered with the reference to the design normal operation conditions specified in item 3.2.1 of the Technical specification:

1. operation at power (includes operation mode at four loops and operation mode with incomplete number of loops);
2. reactor is at MCL of power;
3. «hot» condition;
4. «cold» condition;
5. shutdown for maintenance;
6. refueling.

1.3 This document defines the main procedures on revealing and elimination of defects and maintenance of APCS subsystems and facilities. The actions of the personnel on estimation of the necessity in the Unit unloading, safety systems trial and so on, based on APCS condition evaluation are defined in the basic part of the specification.

1.4 These provisions refer to the automation means and facilities included to APCS of the Unit:

* TLSU;
* CPS EE;
* CSS including initiating and executive part of ESFAS and EP/PP;
* MCDS;
* I&C RC, I&C TC, and I&C EP, I&C V, I&C TG;
* On-line control means at MCR and ECR;

*APPENDIX K CONTINUATION*

* RMS, AFPS.

1.5 Serviceability of APCS and its components including PI shall be estimated by:

* Correspondence to the defined norms of accuracy, reliability and timing characteristics established in the log-forms for SHW or subsystems;
* readiness for operation as per the design algorithms;
* completeness of performing the functions as defined by the design and OD.

Serviceability of MC, PI, AC, alarm and remote control shall be confirmed by relevant printouts of APCS archive after checks.

1.6 Soft-and hardware functioning shall be continuously monitored from AWS AERMS in the scope of diagnostics envisaged in the design and OD.

1.7 Norms of the measuring channels accuracy shall be provided by departmental or state metrological MC verification during SPM. The required norms are specified in Table К.1.

Table К.1

|  |  |  |
| --- | --- | --- |
| Parameter description | The basic measurement error not more, % | |
| Protections and interlocks | Parameter presentation |
| Temperature | ± 1,5 | ± 2,0 |
| Pressure, pressure differential | ± 1,0 | ± 1,5 |
| Level | ± 1,0 | ± 1,5 |
| Flow-rate | ± 4,0 | ± 4,0 |
| Boron concentration | ± 4,0 | ± 4,0 |
| Chemical parameters | ± 6,0 | ± 6,0 |
| Н2, О2 concentration | ± 6,0 | ± 6,0 |
| Humidity | ± 6,0 | ± 6,0 |
| Current, voltage, active power | ± 2,0 | ± 2,0 |
| Note. The table specifies accuracy norms for parameters presentation at the monitors of MCR, ECR workstations. The a.m. accuracy norms refer to the upper value of MC scale. | | |

2 The main provisions on PI operation

2.1 The requirements to maintenance of protections and interlocks refer to:

- emergency protections (EP), preventive protections (PP) and the accelerated Unit unloading system (APP) and ROM;

- safety systems (CSS) protections and interlocks;

- protections and interlocks of the normal operation systems (NOS).

2.2 The protections and interlocks shall be in operation within all operation period of the equipment at which they are installed, except for:

- PI failure reveal;

*APPENDIX K CONTINUATION*

- changeover of the relevant process equipment to "maintenance" mode as per approved "Operating Instruction..." for this equipment;

- at the pulse line check or repair, "zero" check, PT replacement at the group pulse take-off device;

- tripping of individual PI as per the requirements of the operating instruction for the reactor plant at reactor plant changeover to the other operational conditions.

2.3 Organizational measures related to withdrawal of protections for maintenance and their subsequent activation or malfunction elimination shall be taken by dictation of CEP as per the procedure established at NPP and taking into regard the requirements of the specification.

2.4 At checking the protection or interlock at the functioning equipment, which is related to the protection transfer to a signal at activation of the emergency or warning alarm related to the withdrawn protection, the operative personnel shall take actions as per the operating instruction.

2.5 In conditions 1, 5 and 6, the personnel may withdraw PI from operation, except for PI of duty safety system equipment and functioning equipment.

2.6 The following methods are established for activation of the protections and interlocks and their withdrawal from operation for works conduction:

- “electrical connection” control from AWS SERC, AWS SETC;

- programmer activation.

2.7 The activities on the protections activation and withdrawal shall be performed upon SSU decision, it shall be recorded in TLSU archive and the log-book on PI activation-withdrawal.

2.7.1 The procedure of PI activation-withdrawal shall be in compliance with OD.

2.7.1.1 Activation and de-activation of protections through control by «trims» must be performed in the following manner:

Activation and de-activation of protection is performed by the shift operating personnel from the video frame of AWS (reactor operator/turbine operator) by means of activation and de-activation of a relative trim. Activation of protection at reactor operator AWS is performed by setting of the trim value "0", at turbine operator AWS by the trim value "1". De-activation of protection at reactor operator AWS is performed by setting of the trim value "1", de-activation of protection at turbine operator AWS is performed by setting of the trim value "0".

Prior to protection activation the following actions shall be made:

- through APCS SS check absence of signals actuation through the measuring channels involved in generation of protection algorithm;

- if the protection algorithm being actuated has the indication «protection to signal» on video frame, it is necessary to make sure that this signal is not actuating.

2.7.2 Withdrawal of the protection or the protection channel using the programmer activation and simulation of the required parameters is allowed for NO in all conditions, for SS -in conditions 1, 2, 5 and 6. Application of the programmer (installation and removal) shall be recorded.

*APPENDIX K CONTINUATION*

2.7.3 Application of the programmer to activate and withdraw PI, simulate analog and discrete signals as well as application of the other servicing facilities shall be licensed for the relevant activities and justified by verification reports.

2.8 For EP/PP the following is envisaged:

- withdrawal of one MC at failure of PT, PPPE and SLPE devices in it;

- withdrawing the set from operation for the time of detecting the failure and checking CPS EE executive part.

2.9 If the a.m. methods are inapplicable for PI failure checking and elimination including its executive part at the operating Unit and the remote control, its tripping is allowed in conditions 1, 5 and 6 by the regular means of object actuation circuits or disconnection of individual cable wires, taking measures providing for the consequent control of input circuits connection with the recording in the relevant log-book. It is not allowed to disconnect the control and instrumentation circuits at the functioning equipment, except for the special terminals of the

analog signals.

2.10 Replacement of the faulty TPTS modules shall be performed by the personnel observing the requirements of the operating instructions without disconnection of the whole rack.

2.11 SSU shall be notified on failures detected by self-diagnostics or revealed by the personnel during maintenance, and effect to CSS functioning shall be estimated.

2.12 In cases, when the defect in PI shall not cause ESFAS serviceability loss, extraordinary trial of the other SS channels is not envisaged.

2.13 In cases of the Unit operation mode deviation from the operational limits and conditions, scheduled periodic maintenance shall be terminated and serviceability of the systems being checked shall be recovered.

2.14 Prior to the Unit startup after SPM or overhaul, the Unit PI shall be tried in the full scope. It is allowed to perform PI trial in parts: separate trial of MC, LP, executive part, by measure of the equipment and parameters readiness for the check.

2.15 Prior to decoupling protection activation, the readings of the measuring channels at the individual devices and those at TLSU workstations monitors shall be compared, and it shall be confirmed that discrepancy of the analog signals measured by sensors controlling one and the

same parameter and used in the channels of protections, interlocks, indicators, and recorded in TLSU is within the accuracy norm and, if required, the discrepancy signals shall be eliminated.

2.16 In cases, when during PI trial, availability of failures in TLSU or in signalization is revealed, which prevented obtaining of complete recording of their operation, the failures shall be eliminated. After that, PI shall be retried in respect of passing of the unrecorded signals.

2.17 At trial of the multi-channel protections and interlocks ("2 of 3" or "2 of 2"), the following shall be checked:

- inactivation of the protection at the by-turns activation of each channel;

- inactivation of the protection or its channel in absence of each of its activation conditions or availability of disable for its functioning;

*APPENDIX K CONTINUATION*

- activation of the protection at any combinations of channels ("1 and 2", "1 and 3", "2 and 3") and availability of all conditions for its functioning. At the same time, the signal on one sensor failure shall be controlled.

2.18 At trial of the multi-channel protections and interlocks equipped by three parameter control sensors, and the activation setpoint of which is compared with the average value with deduction of the faulty sensor, the following shall be checked

- inactivation of the protection at the signal on one MC activation;

- inactivation of the protection in absence of its activation conditions or availability of disable for its functioning;

- activation of the protection at MC signals exceeding the setpoint and availability of all conditions for its functioning. At the same time, the signal on one sensor failure shall be controlled.

2.19 During trial of several protections having common output commands at the shutdown equipment, it is sufficient to perform one check of effect to common executive part.

2.20 At availability of several dual-redundant circuits generating commands by protections and interlocks for valve or mechanism control, serviceability of each of them shall be checked at the shutdown Unit during the relevant maintenance.

3 Maintenance types, volume, periodicity

3.1 PI maintenance shall be preformed in the following cases:

- prior to activation of the process systems, at the Unit shutdown for SPM;

- prior to startup after idling from 3 to 10 days (see item 3.4);

- prior to startup after idling more than 10 days. (see item 3.3);

- periodically at the operating Unit, EP in respect of EP executive part, as per the approved maintenance schedules;

- prior to activation of the systems and units at the operating Unit;

- prior to PI activation after repair activities in PI circuits at the operating Unit;

- as the result of defects revealed during self-diagnostics or by the personnel;

- in special cases, at malfunctions in the equipment operation, change of conditions or setpoints for activation of the protections and interlocks;

- after the Unit shutdown related to process emergency of faulty equipment;

- after changes in PI activation conditions or circuitry solutions.

3.2 Prior the Unit startup after annual SPM, PPI of the Unit shall be checked in the full scope.

3.3 Prior to the Unit startup after idling more than 10 days (between the annual SPM), the following maintenance activities (MA) shall be arranged:

- maintenance 5 for two EP-PP, APP sets;

- PPI of the system and units withdrawn for repair shall be checked;

- PPI in circuits of which the works have been performed shall be checked;

*APPENDIX K CONTINUATION*

- the defects shall be eliminated, PPI for which the signals on malfunctioning are available shall be checked /except for MC mismatching/;

- PPI shall be checked of one ESFAS channel systems and units, which shall be tried first as per the schedule;

- PPI of ESFIP of all channels and the equipment which is not to be checked at the operating Unit shall be checked.

3.4 Prior to the Unit startup after idling from 3 to 10 days, the following MA shall be performed:

- maintenance 5 for two EP sets;

- PI of the system and units withdrawn for repair shall be checked;

- PI in circuits of which the works have been performed shall be checked;

- the defects shall be eliminated, PI for which the signals on malfunctioning are available shall be checked /except for MC mismatching/.

3.5 Periodicity of PI maintenance at the operating Unit is specified in Table К.2.

Table К.2

| MA type | Maintenance | Periodicity |
| --- | --- | --- |
| MA 1 | 1 Control of parameters, valves position, and indication boards on the safety and normal operation panels.  2 Control for signalization logs and integrated video-frames.  3 Trial of indication boards and sound and alarm indicators.  4 Control for MCDS condition | Once per shift  Continuously, at sound occurrence signal  Once per shift  Once per shift in scope of OM requirements |
| MA 2 | 1 Control for discrete and analog signals at trial the safety system channels as per TLSU printouts.  2 Control for parameters correspondence at the individual SP devices and WS monitors and elimination of defect at violation of the accuracy norms specified in Table К.1.  3 As for ICIS – checks within the scope of requirements to EP, PP checks. | Once in 720 hr |
| MA 3 | 1 Trial of the remote control disables and SS equipment remote control (by-turns from MCR and ECR)  2 Changeovers of the standby automation means (changeover from the operating server, switchboard and LAN to the standby ones): RCD, CPS EE, TLSU and MCDS.  3 Check of EP executive part (once in 6 months) | Once in 2160 hr or at the extra shutdown |

*APPENDIX K CONTINUATION*

Table К.2 continuation

|  |  |  |
| --- | --- | --- |
| MA type | Maintenance | Periodicity |
| MA 4 | Blow-down of the pulse tubes | Once after SPM for PT of pressure differential and upon elimination of MC defect for all PT, if required. |
| MA 5 | Complex testing of protections and interlocks, remote control and process signalization | At least once every 1,5 year and prior to startup after SPM after more than 10 days shutdown.  As for EP/PP, the checks shall be performed considering i.i 3.2, 3.3, 3.4 of this Appendix К |
| MA 6 | Routine maintenance of SHWS means in the scope of APCS operating instruction requirements | At least once every 1,5 year |

Note: Maintenance of APCS systems and equipment not comprised into Table K2 shall be performed separately as per existing operating instructions.

3.6 Deviation form the terms of scheduled PI maintenance is allowed:

- up to 10 days for the maintenance with periodicity of one month;

- up to one month for the maintenance with periodicity of 6 and more months.

3.7 If within 10 days after the deadline of the scheduled maintenance with periodicity of one month the scheduled shutdown of a facility or of the Unit is expected, the check shall be shifted to the shutdown period.

3.8 If ten days prior to the scheduled maintenance, the check of process protections and interlocks was performed at the shutdown, which is confirmed by the relevant documents, it is allowed not to perform the upcoming maintenance at the operating Unit.

3.9 Prior to activating the units and systems at the operating Unit, PI of the equipment, which was withdrawn for repair, shall be checked.

3.10 PI in the circuits of which the works have been conducted at the operating Unit shall be tried.

3.11 During maintenance due to revealed defects, the revealed defects shall be eliminated, al circuits and hardware accessed by the personnel shall be checked. All active and passive elements involved into circuit of the data and commands receiving, processing and implementation shall be subjected to trial.

3.12 After shutdown related to process emergency or failure of the equipment, PI shall be checked as per the specially developed programs.

3.13 Maintenance of PI at the shutdown Unit or of individual unit, system during the Unit operation, as well as in PI circuits at the operating Unit including the activities related to elimination of failures in PI circuits shall be performed as per the established periodicity and scope of (see Table К.2) in compliance with the specially developed programs observing the safe operation limits and conditions.

*APPENDIX K CONTINUATION*

3.14 Extraordinary maintenance shall be performed as per the special programs at changing of setpoints, algorithms, operating conditions or design solutions. At the same time, MA5 shall be performed in the scope of the process equipment, to which can be effected by the introduced changes.

3.15 Trial of safety channels related to ECCS shall be performed by-turns in compliance with the schedule as per the following procedure:

- simulation of one of protections activation /by-turns, except for the protections actuating closing of the isolation valves/;

- check of the relevant equipment activation;

- disconnection of 10 kV power feeding from MCR and ECR / two months from MCR and once a quarter from ECR /;

- check of the require load shedding from the section and sequential startup of the units.

4 Safe operational limits and conditions

Therein under, the safety operation conditions (SOC) are defined and the time limits for elimination of defects are specified.

In case of non-fulfillment of the required actions within the specified time, the actions of the personnel on the Unit unloading, changeover to the other conditions and etc. are defined in section 5 of the process part of the specification and by the operating instructions for the relevant process equipment.

If one of ESFAS functions failed, the channel shall be considered as faulty and the other SS channels shall be tried for this function.

If the environmental parameters are exceeding the limits specified in TU or OD within 6 hours, or power supply parameters exceed the permissible limits, the measures shall be taken on recovery of the operating parameters, and until the a.m. deviations are eliminated, the relevant systems shall be considered as faulty.

4.1 The Engineering Safety Features (ESF).

The system comprises PT, ESFIP, ESFAS, RCD and control and instrumentation devices at the safety panels, as well as cable connections.

SOC: ESFAS shall be serviceable as per the requirements of Table К.3.

Applicability: conditions 1, 2, 3, 4, 5 and 6.

The following are referred to the redundant elements:

- PT, at tripling or doubling the sensors;

- ESFIP included to PPPE and SLPE;

-RCD/ except for RCD-03/;

-ESFAS as for the redundant modules;

- equipment feeding ESFAS, RCD, ESFIP, MCR and ECR.

The list of the redundant equipment shall be available in OD.

The actions and the time for elimination of the defects are specified in Table К.3.

*APPENDIX K CONTINUATION*

Table К.3

| Condition | Required action | Fulfillment period |
| --- | --- | --- |
| A. ESFAS of one SS channel is faulty by one of the process functions due to the defect of the non-redundant facilities or two defects | A1. Actions of the operator are defined by the main part of the specification /see section 5.1.3.1/  AND  A2. Perform works on serviceability recovery and maintenance in the scope of trial by the function in which the defect has been eliminated | 24 hours |
| В. A defect in the redundant part of one SS channel ESFAS equipment | В1. Perform works on recovery and maintenance | 72 hours |
| С. Two safety channels related to ESFAS system are faulty by one of the process functions due to the defect of the non-redundant facilities or two defects | С1. Actions of the operator are defined by the main part of the specification /see section 5.1.3.1/  AND  С2. Perform works on serviceability recovery and maintenance in the scope of trial by the function in which the defect has been eliminated in one of two channels | 24 hours |
| D. failure of one of three MC by one parameter in one SS channel | D1. Check absence of signals on failure in other  AND  D2. perform procedures on serviceability recovery and make sure in absence of defects upon work completion | 24 hours |
| E. Failure of DDLH related to ESFIP signals | E1. Perform works on recovery and maintenance in the scope of trial by the function in which the defect has been eliminated | 72 hours |
| Note. At failure of one of three PT located in the containment, the defect may be eliminated during the first Unit shutdown provided the control measures for this ESFAS channel are toughened or this MC is brought to the activated condition | | |

4.2 TPTS-based control and monitoring systems of normal operation

The systems comprise PT, TPTS including locks and power cabinets, and control and instrumentation means at MCR panels and consoles, as well as communication cable connections.

I&C shall be serviceable as per the requirements of Table К.4.

*APPENDIX K CONTINUATION*

Applicability: conditions 1, 2, 3, 4, 5 and 6.

The following are referred to the redundant elements:

- PT, at tripling or doubling the sensors;

- TPTS as for the redundant modules;

- equipment feeding TPTS, MCR and ECR.

The list of the redundant equipment shall be available in OD.

Applicability: conditions 1, 2, 3, 4, 5 and 6.

The actions and the time for elimination of the defects are specified in Table K.4.

Table К.4

| Condition | Required action | Fulfillment period |
| --- | --- | --- |
| А. A part of I&C system is faulty by one of the process functions due to the defect of the non-redundant elements | А1. Perform works on serviceability recovery and maintenance in the scope of trial by the function in which the defect has been eliminated | 24 hours |
| В. A defect in the redundant part of TPTS equipment | В1. Perform works on recovery and maintenance | 72 hours |
| С. Failure of one of 2 or 3 sensors in PI circuits or pulse line to it or in the information input cable to TPTS | С1. Perform works on recovery and maintenance in the scope of trial by the function in which the defect has been eliminated.  If the signal is used in the protection, transfer it to the signal for the time of work performance.  OR  С2. Upon directive o SSU for the redundant equipment, withdraw the equipment to repair, and perform works on recovery and maintenance in the scope of trial by the function in which the defect has been eliminated at the shutdown equipment. | 72 hours |
| D. Blow-down of pulse-line to one of two or three PT /sensors/ for information input to TPTS | D1. If the signal is used in the protection, transfer it to the signal.  AND  D2. Perform works on recovery and maintenance in the scope of trial by the function in which the defect has been eliminated | 72 hours |

*APPENDIX K CONTINUATION*

Table К.4 continuation

| Condition | Required action | Fulfillment period |
| --- | --- | --- |
| Е. Failure in one device or set of devices at MCR | Е1. Perform works on recovery and maintenance in the scope of trial by the function in which the defect has been eliminated | 72 hours |
| Notes. The maximal time allocated for elimination of a defect or failure shall be counted from the moment of revealing the event.  The defective element shall be revealed within not more than 8 hours included into total time for elimination of the defect  In case of impossibility to repair the defect within the authorized time, perform planned changeover of the RP to mode 4 | | |

4.3 Emergency protection system

Emergency protection system includes the following equipment:

1) initiating part (two three-channel sets of the equipment). Each set of the equipment includes:

- primary transducers including seismic control facilities;

- neutron flux measuring equipment;

- process parameters protection equipment (3 cabinets of EP, PP PPPE);

- protection signal logical processing equipment (3 cabinets of EP, PP SLPE).

2) executive part (two sets of the equipment). Each set includes:

- emergency command shaping devices (2 cabinets of SHAK1M);

- power contactor control device (2 cabinets of SHPUK);

- the cabinet with a.c. power contactors (2 cabinets of SHP6M);

- the cabinet with d.c. power contactors (2 cabinets of SHP6M1)

the emergency reactor manual trip keys (2 keys at MCR and 2 keys at ECR).

Safety operation conditions: the emergency protection system shall be serviceable as per the requirements of Table К.5 as well as in compliance with Table 5.1.3.1 in section 5 of this specification.

Applicability: Unit conditions 1 and 2.

In conditions 1-5, the facilities providing information representation at MCR and ECR shall be serviceable.

In conditions 1-6, the facilities providing for the equipment tripping and information representation at seismic effects shall be serviceable.

Table К.5 contains the list of the required actins of the operative personnel during operation at the energy levels of power depending on the makeup of the serviceable equipment in the reactor emergency protection system.

*APPENDIX K CONTINUATION*

Table К.5

|  |  |  |
| --- | --- | --- |
| Condition | Required action | Fulfillment period |
| А. Failure of the neutron flux detecting units (startup and operating ranges) in one of ex-core channels or failure in one of NFME DAPD during operation at power | A1. Withdraw the set for repair  and  A2. Eliminate the failure in NFME DAPD, perform repair within MC check and activate it  A3. If А1 and А2 are not fulfilled within the defined time, and if there are no signals on failure in the second set, changeover SLPE cannel to activated condition and continue to eliminate the defect  А4. If А3 is not fulfilled within the defined time– The actions of personnel are defined in the main part of the specification. | 8 hours    Immediately |
| В. Failure of the neutron flux detecting units (in startup range or source range) in one of the ex-core channels or failure in one of NFME DAPD cabinets at the power level as  (10-8 - 10-2) % Nnom | В1. Withdraw the set for repair, trip the faulty MC / NFME DAPD cabinet, or NFME DAPD cabinet with faulty detecting unit /.  AND  В2. Stabilize power at level not more than 10-2 % Nnom  AND  В3. Eliminate NFME failure, perform maintenance and put NFME DAPD cabinet into operation or connect standby units  В4. If B3 is not fulfilled within the defined time – The actions of personnel are defined in the main part of the specification. | 8 hours    Immediately |
| С. One channel of the emergency manual shutdown of the reactor is faulty | С1. Recover serviceable condition of the channel  С2. If С1 is not fulfilled within the defined time – The actions of personnel are defined in the main part of the specification. | 24 hours Immediately |

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| *APPENDIX K CONTINUATION*  Table К.5 continuation | | |
| Condition | Required action | Fulfillment period |
| D. One emergency protection channel (EP PPPE and/or EP SLPE) in the first set is faulty and/or one emergency protection channel ((EP PPPE and/or EP SLPE) in the second set is faulty | D1. Withdraw the channel for repair.  AND  D2 Recover serviceable condition of the channel, perform maintenance and put EP PPPE and/or EP SLPE cabinets into operation  D3. If D1 and D2 are not fulfilled within the defined time – The actions of personnel are defined in the main part of the specification. | 8 hours  Immediately |
| Е. Withdrawal of one EP set for checking (simultaneously only one channel of initiating part may be withdrawn for checking) provided that protections in the other EP channel are serviceable | Е1. Check the withdrawn channel and make sure in its serviceability  Е2. If Е1 is not fulfilled within the defined time – The actions of personnel are defined in the main part of the specification. | 8 hours  Immediately |
| F. Two and more channels in different sets (initiating part) are faulty (failure after making a request) | F1. Emergency shutdown of the reactor by the button for manual emergency shutdown of the reactor | Immediately |
| G. Failure in one of the executive part sets | G1. Withdraw the set for repair and do not take any actions on changing the Unit power  AND  G2. Elimination of failure  AND  G3. If G1 and G2 are not fulfilled within the defined time – The actions of personnel are defined in the main part of the specification. | 8 hours  Immediately |
| K. Failure of two executive part sets | K1. Emergency shutdown of the reactor by the button for manual emergency shutdown of the reactor or by CPS EE de-energizing | Immediately |
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| *APPENDIX K CONTINUATION*  Table К.5 continuation | | |
| Condition | Required action | Fulfillment period |
| L. One of three MC is faulty by one parameter in one set in the pulse part. | L1. Check absence of signals on failure in EP sets.  AND  L2. Changeover to the activated condition the channel of two EP sets which is faulty by this parameter, and perform procedures on its recovery, make sure in absence of defects upon work completion and put the channel of two EP sets to operation  L3. If L1 and L2 are not fulfilled within the defined time – The actions of personnel are defined in the main part of the specification. | 24 hours  Immediately |

4.4 MCDS is monitoring control and diagnostics system functioning within APCS.

MCDS includes the following subsystems and software-hardware complexes:

- in-core instrumentation system (ICIS);

- vibration monitoring system (VMS);

- RCPS vibration monitoring subsystem (VMS-RCPS);

- RP primary circuit coolant leakage monitoring subsystem (LMS);

- loose part detection subsystem (LPDS);

- complex analysis server.

In-core instrumentation system (ICIS) includes:

- primary transducers;

- SHWC performing functions of the core emergency and preventive protection signals shaping and sending to EP-PP SLPE at linear power-flux exceeding the permissible limits, at DNB heat flux margin decreasing below the permissible limits (SHWC-З) in the amount of 6 cabinets;

- SHWC performing informational-and controlling functions (SHWC–IC), in the amount of two cabinets;

- SHWC performing functions of SPND variable composing signals processing (SHWC-ICND), in the amount of two cabinets;

- terminal cabinet providing multiplication of input signals for SHWC-IC;

- lower level local-area network (LL LAN) of the type CAN (ISO 11898), intended for data exchange between SHWC-P, as well as between SHWC-IC;

- upper level computing complexes ULLC in the amount of two servers (ULLC No.1,ULLC No.2);

*APPENDIX K CONTINUATION*

- local-area network ICIS LAN (IEEE802.3, TCP-IP protocol) consisting of two ICIS switchboard located in ULLC No.1 and ULLC No.2, network cards and network SW installed in network clients, optical communication cables and cross-optical cabinets (COC). ICIS LAN is a redundant galvanic-decoupled network, by which data exchange is performed between SHWC-ICIS hardware, between SHWC ICIS hardware and the other MCDS subsystems.

Safety operation conditions as well as degradation stages are specified in Appendix J

4.5 Refueling monitoring equipment.

Refueling monitoring system consists of two three-channel sets. Each channel consists of detecting units, rating converters, and the secondary measuring equipment. The system sets include also signaling facilities (lighting panel «stop», «reverse» and acoustic means), located at MCR, refueling machine console and at the duty physics, which allow to monitor thermal neutron flux density at refueling.

At least one set of the refueling monitoring system shall be serviceable in the Unit operational conditions 5 and 6.

Applicability: conditions 5 and 6.

The required actions and time for their fulfillment are specified in Table К.6.

Table К.6

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| Condition | Required action | Fulfillment period |
| А. One refueling control channel is faulty | А1. Recover serviceability of the channel | Unit the failure is eliminated |
| В. Two and more refueling control channels are faulty | В1. Terminate refueling  AND  В2. Recover serviceability of the channels | Unit the failure is eliminated |
| С. One optics-and acoustic indicator is faulty | С1. Recover serviceability of the indicator | Unit the failure is eliminated |

4.6 The reactor preventive protection system and ROM instrumentation

Preventive protection system includes the following equipment:

1) initiating part (two three-channel sets of the equipment).

Each set includes:

- primary transducers;

- neutron flux control equipment;

- process parameters protection equipment PPPE/common for EP, PP/;

- protection signal logical processing equipment SLPE / common for EP, PP/;

2) executive part (two sets of the equipment).

Each set includes:

- emergency command shaping device (4 cabinets of SHAK1M, common for EP and PP);

- command shaping device PP-1, PP-2 (PRSM cabinet);

*APPENDIX K CONTINUATION*

- command shaping device APP (PRSMU cabinet).

ROM instrumentation includes the following equipment:

1) initiating part (two three-channel sets of the equipment);

2) logical processing equipment and the executive part are common with the preventive protection system.

At least one set of the reactor preventive protection system and ROM instrumentation shall be serviceable in the Unit operational conditions, as per Table К.7.

In conditions 1-5, the facilities providing for the information representation at MCR and ECR shall be serviceable.

4.7 System of CPS CR drive group and individual control

System of CPS CR drive group and individual control includes the following equipment:

- 2 cabinets PP26M

- cabinet PP28M

- cabinet PP29M

- cabinet PP30M

- 2 cabinets of RMSC servers

- 11 control and monitoring cabinets PKU1M;

- 21 CPS CR power control cabinet PSU2M

- Monitor, Individual selection panel, command keys and MCR

- CPS CR position indicators at MCR and ECR

- CPS CR control modes switchover keys

The system of CPS CR drive group and individual control related to normal operation systems shall be serviceable in the Unit operational conditions 1, 2 in compliance with Table 5.1.3.1 in section 5 of this specification.

4.8. Automatic RP power controller /APC/

Automatic reactor plant power controller consists of two identical two-channel automatic power controllers APC 6М

APC related to normal operation device shall be serviceable in the Unit operational condition 1 as per Table 5.1.3.1 of section 5 of these technical specifications.

4.9 TLSU

TLSU is the normal operation system, it shall be serviceable to fulfill the defined functions with the required quality as per Table K10.

Applicability: conditions 1, 2, 3, 4, 5 and 6.

The actions and time for elimination of defects are specified in Table К.10.

*APPENDIX K CONTINUATION*

Table К.10

| Condition | Required action | Fulfillment period |
| --- | --- | --- |
| А. A part of TLSU system / Workstation/ is faulty by one of the functions due to the defect of non-redundant facilities in conditions 2,3,4. | А1. Perform works on serviceability recovery and maintenance in the scope of trial by function in which the defect is eliminated  AND  А2. Produce the required information at the serviceable monitors, including the signalization log | 72 hours  Until the defect is eliminated |
| В. The defect in the redundant part of the equipment /server, switchboard, LAN/ | В1. Perform works on recovery and maintenance | Until the defect is eliminated |
| С. A part or all TLSU system is faulty by on of the control and monitoring functions, which does not allow to obtain the required information or give a command at ERC or ETC workstation | С1. Stop the actions on changing the Unit operation mode  AND  С2. Perform works on serviceability recovery and maintenance in the scope of trial by function in which the defect is eliminated  С3. If С2 is not fulfilled within the defined time – changeover the Unit to condition 3 using redundant area and GMP. | Immediately  2 hours  Immediately |
| D. SS APCS workstation is faulty by one of the functions due to the defect of non-redundant facilities. | D1. Eliminate the defect. For the time of elimination take the organizational measures to monitor for APCS facilities | 72 hours  /In conditions 1, 5 and 6 – until the defect is eliminated/ |

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1. \* «Local uncontrolled section» is a core section, in which all FA adjacent to FA uncontrolled due to ICDS failure are also uncontrolled due to failure of the relevant ICDS. FA shall be considered uncontrolled by the reason of ICDS failure, if among six ICDS controlling it, four (or more) are faulty. ICDS shall be considered faulty, if two or more SPND in it are faulty. [↑](#footnote-ref-2)