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WORKSHOP ON ADVANCED NUCLEAR POWER PLANT SIMULATION

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Training tasks for investigation of physical and operation characteristics of VVER-1000 reactor

BRIEF DESCRIPTION

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These are preliminary lecture notes, intended only for distribution to participants

Training tasks for investigation of physical and operation characteristics of VVER-1000 reactor.

Brief Description

The document provides a brief description of training tasks that were included in the Task Manager program (PZ) in the form of scripts. You may run each of them automatically by double clicking its icon from PZ, investigate processes, characteristics, actions, protocols, etc. After that try to fulfill actions that are carried out automatically from script, manually. For that it is needed to run training task "*Rated state operation. 1st core-loading*" (for the 1st core loading) or "*Rated state operation. 5th core-loading*" (for the 5th core loading). This is steady state of reactor operating at rated power without any script.

Actions performed within similar tasks for the 1st and for the 5th core loadings are mainly the same.

Exercise 01

a) "A03 Reactivity effects for BOC"

b) "A04 Reactivity effects for EOC"

BOC. Determination of scram (EP) control rods "weight". Determination of power reactivity factor (fuel temperature + coolant temperature). Determination of iodine poisoning. Determination of core unpoisoning. Comparison of reactivity factors and scram control rods "weight" for the 1^{st} and for the 5^{th} core loadings.

EOC. Determination of scram (EP) control rods "weight". Determination of power reactivity factor (fuel temperature + coolant temperature). Determination of iodine poisoning. Determination of core unpoisoning. Comparison of reactivity factors and scram control rods "weight" for the 1^{st} and for the 5^{th} core loadings.

Exercise 02

a) "A01 burnup without failure of the ex-core monitoring system"

b) "A02 burnup with failure of the ex-core monitoring system"

Fuel burnup at steady rated power with full dilution (removal) of boron and stretching out fuel cycle lowering power to 70% of rated power due to negative temperature factor. It is assumed to investigate stationary core characteristics, spatial non-uniformity factors, power offset, comparison with limiting values for normal operation at rated power and for limiting values with partial failure of neutron flux monitoring system. Compare stretching out fuel cycle for the 1st and for the 5th core loadings.

2

Exercise 03

- a) "A05 Xenon (power and offset) oscillations for BOC"
- b) "A06 Xenon (power and offset) oscillations for EOC"
- c) "A07 Xenon (power and offset) oscillations for MOC"

BOC. Actuation of URB (AUU) (automatic fast reducing neutron power in reactor). Switching off ARM (ACP) (automatic reactor power regulator). Freezing all reactor protection systems. Investigation of power and offset oscillations. Comparison of oscillations for the 1st and for the 5th core loadings and for different moments of core cycle. Investigation of reasons for oscillations.

MOC. Actuation of URB (AUU) (automatic fast reducing neutron power in reactor). Switching off ARM (ACP) (automatic reactor power regulator). Freezing all reactor protection systems. Investigation of power and offset oscillations. Comparison of oscillations for the 1st and for the 5th core loadings and for different moments of core cycle. Investigation of reasons for oscillations.

EOC. Actuation of URB (AUU) (automatic fast reducing neutron power in reactor). Switching off ARM (ACP) (automatic reactor power regulator). Freezing all reactor protection systems. Investigation of power and offset oscillations. Comparison of oscillations for the 1st and for the 5th core loadings and for different moments of core cycle. Investigation of reasons for oscillations.

Exercise 04

"A08 Xenon oscillations of the axial offset at constant reactor power for BOC 1h delay"

BOC. Experiment on excitation of offset oscillations at constant integral reactor power by insertion and withdrawal of control rods group. Lowering reactor power to 70%. Insertion of 10th control rod group from 80% to 40%, exposure at this position within 1 hour, withdrawal this group back to 80%. Power is regulated by boron, using plant boron regulation system or boron regulator of simulator. Investigation of offset oscillations. Comparison of oscillations for the 1st and for the 5th core loadings, for the different moments of core cycle, and for different time of inserted control rod group exposure.

"A09 Xenon oscillations of the axial offset at constant reactor power for BOC 4h delay"

BOC. Experiment on excitation of offset oscillations at constant integral reactor power by insertion and withdrawal of control rods group. Lowering reactor power to 70%. Insertion of 10th control rod group from 80% to 40%, exposure at this position within 4 hours, withdrawal this group back to 80%. Power is regulated by boron, using plant boron regulation system or boron regulator of simulator. Investigation of offset oscillations. Comparison of oscillations for the 1st and for the 5th core loadings, for the different moments of core cycle, and for different time of inserted control rod group exposure.

"A10 Xenon oscillations of the axial offset at constant reactor power for BOC 8h delay"

BOC. Experiment on excitation of offset oscillations at constant integral reactor power by insertion and withdrawal of control rods group. Lowering reactor power to 70%. Insertion of 10th control rod group from 80% to 40%, exposure at this position within 8 hours, withdrawal this group back to 80%. Power is regulated by boron, using plant boron regulation system or boron regulator of simulator. Investigation of offset oscillations. Comparison of oscillations for the 1st and for the 5th core loadings, for the different moments of core cycle, and for different time of inserted control rod group exposure.

"A11 Xenon oscillations of the axial offset at constant reactor power for EOC 1h delay"

EOC. Experiment on excitation of offset oscillations at constant integral reactor power by insertion and withdrawal of control rods group. Lowering reactor power to 70%. Insertion of 10th control rod group from 80% to 40%, exposure at this position within 1 hour, withdrawal this group back to 80%. Power is regulated by boron, using plant boron regulation system or boron regulator of simulator. Investigation of offset oscillations. Comparison of oscillations for the 1st and for the 5th core loadings, for the different moments of core cycle, and for different time of inserted control rod group exposure.

"A12 Xenon oscillations of the axial offset at constant reactor power for EOC 4h delay"

EOC. Experiment on excitation of offset oscillations at constant integral reactor power by insertion and withdrawal of control rods group. Lowering

reactor power to 70%. Insertion of 10th control rod group from 80% to 40%, exposure at this position within 4 hours, withdrawal this group back to 80%. Power is regulated by boron, using plant boron regulation system or boron regulator of simulator. Investigation of offset oscillations. Comparison of oscillations for the 1st and for the 5th core loadings, for the different moments of core cycle, and for different time of inserted control rod group exposure.

"A13 Xenon oscillations of the axial offset at constant reactor power for EOC 1st loading 8h delay"

EOC. Experiment on excitation of offset oscillations at constant integral reactor power by insertion and withdrawal of control rods group. Lowering reactor power to 70%. Insertion of 10th control rod group from 80% to 40%, exposure at this position within 8 hours, withdrawal this group back to 80%. Power is regulated by boron, using plant boron regulation system or boron regulator of simulator. Investigation of offset oscillations. Comparison of oscillations for the 1st and for the 5th core loadings, for the different moments of core cycle, and for different time of inserted control rod group exposure.

"A13 Xenon oscillations of the axial offset at constant reactor power for EOC 1st loading 28h delay "

This task is done only for the 1st loading. BOC. Experiment on excitation of offset oscillations at constant integral reactor power by insertion and withdrawal of control rods group. Lowering reactor power to 70%. Insertion of 10th control rod group from 80% to 40%, exposure at this position within about 28 hours, withdrawal this group back to 80%. Power is regulated by boron, using plant boron regulation system or boron regulator of simulator. Investigation of offset oscillations. The task demonstrates the strategy for Xeoscillation suppression by operator. The best moment to suppress oscillations is when OFFSET has the maximum positive derivative.

Exercise 05

"C01 Hot shutdown and start up without failures at BOC"

Hot shutdown after reactor scram (EP). After stabilization of pressure in the secondary circuit, BRU-K (relief valve of steam dump to condenser) switch to «П» mode, "Auto". Inject boron up to 12 - 16 g/kg. After that start withdrawal of control rods group beginning from 1 to 9. Group 10 stop at height 80%. Start raising reactor power level by boron dilution. Reach reactor criticality (reactivity = 0, reactor period is positive). Save this simulator state. Analyze parameters. Start further raising of reactor power. At 1-5% exposure and saving state. Further power raise up to 35%. Stabilization at this power level. Switch SKTG(turbine stop valves) to "Auto". Switch BRU-K to "Rem", close all 4 BRU-Ks manually. Switch BRU-K in "watch" regime (P1). Analyze parameters. Control rod group 10 should not be lower 70%. If it will appear that it is lower, it will be needed to withdraw it up to 70-80%. Further raising of power up to 75% is carried by boron dilution. Stabilization of offset oscillations. Further raising power level up to 100%. Stabilization of offset oscillations at this level. Switch on ARM (ACP). Analysis of all neutron physics parameters using SVRK tables. Saving simulator state. Analysis of protocol

Free Practice

a) "C02 Hot shutdown and start up with single failure_1 at BOC d) "C03 Hot shutdown and start up with single failure_2 at BOC" d) "C04 Hot shutdown and start up with single failure 3 at BOC"

The task is to determine what equipment failed and try to return it back into operation. Hot shutdown after reactor scram (EP). After stabilization of pressure in the secondary circuit, BRU-K (relief valve of steam dump to condenser) switch to « Π » mode. Introduce boron up to 12 – 16 g/kg. After that start withdrawal of control rods group beginning from 1 to 9. Group 10 stop at height 80%. Start raising reactor power level y dilution boron. Reach reactor criticality (reactivity = 0, reactor period is positive). Save this simulator state. Analyze parameters. Start further raising of reactor power. At 1-5% exposure and saving state. Further power raise up to 35%. Stabilization at this power level by switching on ARM (ACP) (automatic regulator of power). Switch BRU-K in "watch" regime (P1). Switch on turbine stop valves to automatic regime. Analyze parameters. Switch of ARM(ACP). Control rod group 10 should not be lower 70%. If it will appear that it is lower, it will be needed to withdraw it up to 70-80%. Further rising of power up to 75% is carried by boron dilution. Stabilization of offset oscillations. Further raising power level up to 100%. Stabilization of offset oscillations at this level. Analysis of all neutron physics parameters using SVRK tables. Saving simulator state. Analysis of protocol,

VVER-1000 Reactor Department Simulator

Getting Started.

-8.

Tasks - Local reactor part simulator of SUNPP 2 unit
 Local reactor part simulator of SUNPP 2 unit
 Tasks
 Task

To select the task double-click by mouse on the item.

CR groupe state 00:00:16 FA perameters IMS failure AT N P 0 1 01 - 24 Selection << >> 99.3 V ¥ ¥ Ŧ 1.30 01 Ao 📧 Enr 48 100.0 2 02 Burn N₇ Skins Ŧ Y Ŧ * 1.15 03 Tdel Kya: Δ. 1,10 3 04 1.05 Ky Dill Y Ŧ Kq 1.80 05 0.95 10 06 0.90 Ŧ 0.85 07 0.80 0.75 × ¥ Running in non-network mode ۵ Cannot play "\\ets\exchange\bord i,enikotsa\sa ۵ Cannot play "\\ets\exchange\bog din\enikotso\so :Cu 62 . Cannot initialize sound system MSYSTEM002 ŢĻ Model is loaded 2.0 0 Coromodel STATIC Mode Deron 21m mo Marce More 🙆 4 3000 Auto Rem ¥ 99.3 2 40 • < | ≫ * ۸ A 10 32 34 36 34 M ---**1** • VY H ACP لم آ 7 0000:00:16 3 5 Lim 10 model Pl N° Estado T Street Kq Y - X 1 GCP N: **P**2 $\mathbf{C}_{\boldsymbol{\theta}}$ Ky Ste 03-28 80 EP serpoint Ao 🚟 😳 ρ CPS TAB 20.2 **T** : Tdel IND 2 GC 107.0 100 100 ĩC ΤK 1725 77 X 1 GCP TQ TF 101 AUU EP PP << >> GRP 2C ۵ 2 GCP ŵ IN

The Simulator screen formats will be loaded, the system messages will be presented in the **Messages** window.

You may minimize Messages window.

	00:00:00	Real time		
Star/Shop O' = 24 Au Rur 44 Burn Ni 100 Ar 2225 Toel Kq Kur Kur	0 02 03 04			22 16 1.1C 1.Ue 0C
				0.96 0.86 0.86 0.75 0.75
Terxis biliers Polybian Nor i bole Kre i Less i Jess i Cess i N ² F2 E93 min 1: T ACT	12 13 14 15 16 16 16 18 18 18 18 10 10 10 10 10 10 10 10 10 10		BLS 40 42 27 26 33 M _T 1	
Y x 1 € 03-22 50 107.0 100 100 ≤≤ >>>			110 3	C.'S TAE IC TK TQ TF GRP 2C

Move mouse cursor to the top of the screen, control bar will appear. Press button Start/Stop

The model will start running.

12

2. How to Exit.

Move mouse cursor to the top of the screen, control bar will appear.

- 1. Press button **Start/Stop**
- 2. Press button Exit



3. Main elements.



4. Process control.





Click pump with mouse. It will be highlighted, as well as its control panel. You may switch on pump or switch off pump by clicking appropriate button.



Click valve with mouse. It will be highlighted, as well as its control panel. You may start opening valve or start closing valve by clicking appropriate button.



Click regulator with mouse. It will be highlighted, as well as its control panel. You may put regulator in automatic or manual mode by clicking appropriate buttons. In manual mode you can start opening regulator or start closing regulator by clicking appropriate button.



Training exercises using compact computer simulator of VVER-1000 Reactor Department

Special features and regimes

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- 1 Some simulator model variables and their definitions for training lessons to technology of VVER-1000:
- ISHL parameter for turning on the fuel burnup model
- ISHL =1- fuel burnup model is on
- ISHL 0- fuel burnup model is off
- ISTATE parameter for turning on the "STATIC"/"DYNAMIC" option
- ISTATE =1 "STATIC" option is on
- ISTATE =0 "DYNAMIC" option is on
- **PERIOD_F** output variable for the reactor period (sec)
- **REACTIVITY_F** output variable for reactivity (%)
- **CBOLD_F** input variable for boron concentration
- N_POWER_F output variable for neutron power (% from rated nominal power)
- T_POWER_F output variable for thermal power (MW)
- OFFSET output variable for axial power offset (%)
- KQ output variable for the radial power peaking factor, F_{2D}
- KV output variable for the 3D power peaking factor, F_{3D}
- KVCBRK(1:8) axial power distribution for 8 axial nodes in the hot assembly (FA with maximum power)
- TEFF_F core burnup in full power days (FPD)
- ESERG1 coolant mixture enthalpy at core inlet in case of disconnecting the core and circuit models (J/kg)
- GSERG coolant flow rate in case of disconnecting the core and circuit models (kg/sec)
- PNSTATE steady state neutron power for the "STATIC" option (relative units)
- PSERG primary circuit pressure in case of disconnecting the core and circuit models (Pa)
- YSn1Sn2 lz stuck rod position in relative units (0.0-1.0)
- YSn1Sn2_l variable to turn on a control rod failure with coordinates: n1Sn2 where n1 is rod number along the x- axis and n2- rod number along the y- axis (for example: 03S14)
- YSn1Sn2 l = 0 no failure;
- YSn1Sn2 6 =-1 uncontrolled rod withdrawal
- YSn1Sn2 l =-5 stuck rod flag
- YSn1Sn2 1=-3 failure of rod insertion
- YSn1Sn2 1=-4 failure of rod withdrawal
- TB10S26_E valve opening on the pipe between the borated water tank and HPIS line
- TB10S24_E valve opening on the pipe between the borated water tank and HPIS line
- TB10S17_E valve opening on the pipe between the borated water tank and HPIS line
- TB10D02_E pump for injection of borated water into the HPIS line
- TK70S11_E valve opening setpoint on the pipe between clean water tank and primary circuit

- TK70S14_E- valve opening setpoint on the pipe between clean water tank and the primary circuit
- RL31D01 main feedwater pump #1 for the stream generators
- RL32D01 main feedwater pump #2 for the stream generators
- RC12S01_E BRU-K valve opening (steam dump from main steam collector to condenser)
- RC12S02_E BRU-K valve open opening (steam dump from main steam collector to condenser)
- RC11S01_E BRU-K valve open opening (steam dump from main steam collector to condenser)
- RC11S02_E BRU-K valve open opening (steam dump from main steam collector to condenser)
- DT1KONTUR rate of heatup or cooling-down of the primary circuit (C/hour)
- RC11P01 secondary circuit pressure
- YC00P01 primary circuit pressure
- T1KONTUR average coolant temperature in the primary circuit (over all coolant loops)
- TZAP margin to saturation temperature (C)

Limits of volume energy distribution under normal operation conditions:

Through 10 – 50 days after the beginning	In the beginning
%SC_VAR91 =1.90,	%SC_VAR81 =1.85,
%SC_VAR92 =1.90,	%SC_VAR82 =1.85,
%SC_VAR93 =1.90,	%SC_VAR83 =1.85,
%SC_VAR94 =1.85,	%SC_VAR84 =1.80,
%SC_VAR95 =1.75,	%SC_VAR85 =1.70,
%SC_VAR96 =1.65,	%SC_VAR86 =1.60,
%SC_VAR97 =1.55,	%SC_VAR87 =1.50,
%SC_VAR98 =1.40,	%SC_VAR88 =1.35,

Limits of volume energy distribution under Failure of mathematical support of the INRC:

Through 10 – 50 days after the beginning	In the beginning
%SC_VAR71 =1.70,	%SC_VAR61 =1.65,
%SC_VAR72 =1.70,	%SC_VAR62 =1.65,
%SC_VAR73 =1.70,	%SC_VAR63 =1.65,
%SC_VAR74 =1.65,	%SC_VAR64 =1.60,
%SC_VAR75 =1.55,	%SC_VAR65 =1.50,
%SC_VAR76 =1.45,	%SC_VAR66 =1.40,
%SC_VAR77 =1.35,	%SC_VAR67 =1.30,
%SC_VAR78 =1.20,	%SC_VAR68 =1.15,

%SC_VAR69 =11.0, up limit of axial power offset %SC_VAR70 =-5.5; down limit of axial power offset

The axial power distribution for 8 axial nodes in the hot assembly (maximum power) KVCVRK(1-8)

Comparison of this values with given limits is one of the most important tasks.

2 Special features

The following variables representing limits of spatial relative power release in the core, it will be interesting to display on the plot:

%SC_VAR92 – limit for relative volume power at rated state (80%-100%) in the core at the height about 50 cm

%SC_VAR97- limit for relative volume power at rated state (80%-100%) in the core at the height about 280 cm

%SC_VAR72- limit for relative volume power at rated state (80%-100%) in the core at the height about 50 cm under failure of computer data processing system.

%SC_VAR77- limit for relative volume power at rated state (80%-100%) in the core at the height about 280 cm in the core at the height about 50 cm under failure of computer data processing system.

KVCVRK(2) – value of relative volume power release in the core at the height about 50 cm in FA with maximal power

KVCVRK(7) – value of relative volume power release in the core at the height about 280 cm in FA with maximal power

Values of limits can be changed within dialog box for plot editing:

- 1) Press right button of the mouse in the plot window area context menu will appear.
- 2) Select item "Edit plot" edit dialog will appear.
- 3) Click mouse button on the field Name arrows will appear.
- 4) By clicking arrows find needed name. If needed name is absent, find unassigned name (it will appear without name in right column) and type needed name and press Enter.
- 5) You may change value of external variable in the field Value, simply by positioning cursor in the right column of field Value, typing needed value and pressing Enter
- 6) You may select preferred color by positioning to the field color and clicking button ... The new window will appear where you may choose preferred color.
- 7) Values of minimum and maximum in Y axis can be set in the fields Minimum and Maximum.
- 8) You change time scaling in the Time interval.

3 Special simulator regimes

Among distinctive features of this simulator are availability of special simulator regimes providing possibility for fast analysis of long-term processes, easy to use determination of reactivity factors, speeding up calculations and convenient of work.

- <u>Running model in fast-time mode</u> neutron kinetics model can run 30000 faster that is useful for investigation fuel burnup, xenon processes within one session while keeping precision of calculations similar to plant support codes. This can be done by clicking fast time mode bar with mouse. This bar is located right under the core pane. If fast-time factor is greater than 10, disconnection of primary circuit thermalhydraulics and neutron kinetics model will be carried out automatically (this will be displayed by removing highlighting of arrows on the right control bar. Neutron kinetics model will take thermalhydraulics parameters from the last step before disconnection. If fast time mode will be set below 10, models will be automatically connected. Changing of fast-time mode factor is carried out with smoothing (not in one step)
- <u>Running model in stationary regime</u>, Neutron kinetics model can be switched to stationary regime. This option provides possibility of determination reactivity effects and factors for any external parameter. These parameters can be changed:
 - **PSERG**-pressure at the core inlet ,kg/cm**2
 - **ESERG1** enthalpy at the core inlet, J/kg;
 - **GSERG** coolant flow rate through the core, kg/s;
 - **CBOLD_F**, boron concentration g/kg (g of boron to kg of coolant);
 - TINAZ temperature at the core inlet corresponding to enthalpy ESERG1.

For example, disconnect neutron kinetics and thermalhydraulics models by clicking appropriate arrows with mouse. Set variables **ESERG1** and **TINAZ** for displaying on the plot. Normalize maximum and minimum, and change value of enthalpy to another, for example +- 100000. In the result it is very easy to determine temperature factor of reactivity for given reactor power level. This can be done also in dynamic mode. In this case temperature factor of reactivity can be determined approximately considering the change of temperature at the core inlet. Similar action can be performed with other variables: **PSERG, GSERG, CBOLD_F.**

- <u>Switching to automatic maintenance of boron concentration</u> model of boron regulator was added to simulator model. This permits to maintain current power in dynamic model and to maintain critical state of the core in static mode. It is useful when it is needed to regulate manually boron concentration for a long period of time. This will be not plant procedure but it is convenient for analysis of processes in the core, because allow to keep attention on the investigating item. Disconnection with plant boron regulation system is carried out by clicking lower arrows in the right pane ("boron exchange"). After that it is possible to switch regulator to automatic or manual mode. In manual mode it is possible to set any desired value. After that this boron concentration will be set in all systems that should have current boron concentration.
- <u>Switching to fuel burnup mode</u>, provides possibility to simulate fuel burnup at the plant within several months and even for the whole year. It is useful for quick reaching new simulator state on another moment of fuel life cycle within few minutes. It is possible to determine time of fuel life cycle, and possibilities of its prolongation due to the temperature effect. It can help to forecast consequences of some failures (for example, sticking of control rod, MCP trip, etc.), investigate influence of equipment failures on efficiency of the Unit. This mode can be switched on by setting value ISHL=1 (ISHL=0-no fuel burnup) through the plot.

• <u>Tuning neutron kinetics model according to the plant data</u> – tuning is carried out using special screen drawing called: «V_SETUP_ENG», that can accessed only from the menu of upper control bar. The most useful are parameters providing correction of neutron currents in radial and axial directions, and parameters for correction leakage of neutrons to side, top and bottom reflectors. Auxiliary parameters – extrapolation lengths at the side reflector. Their values can change within 10 to 25 cm. This can help to tune real configurations of reflector and core baffle. User can also change kinds of fuel assemblies loaded in the core. This will change neutron physics constants that used for neutron flux calculations for given FA. Number of kinds – 6, that corresponds to the number of types used in this model of reactor (320).

List of main variables for VVER-1000 Reactor Department Simulator

BURNUP CAS	Fuel burnup for monitoring FA	
CAMERA1	readings of ionizing chamber 1	
CAMERA2	readings of ionizing chamber 2	
CAMERA3	readings of ionizing chamber 1	
DT CAS	Coolant heating for monitoring FA	
KO	Maximal assembly-wise non-uniformity factor	
KO CAS	non-uniformity factor for monitoring FA	
KV	Maximal control volume-wise non-uniformity factor	
KV CAS	control volume-wise non-uniformity factor for monitoring FA	
N POWER (%)	Reactor Neutron power	
OFFSET	Offset	
OFFSET CAS	Offset for monitoring FA	
PERIOD (sec)	Reactor period	
PN AX1	axial non-uniformity of neutron flux Kz (section 1)	
PN AX10	axial non-uniformity of neutron flux Kz (section 10)	
- PN AX2	axial non-uniformity of neutron flux Kz (section 2)	
PN AX3	axial non-uniformity of neutron flux Kz (section 3)	
PN AX4	axial non-uniformity of neutron flux Kz (section 4)	
PN AX5	axial non-uniformity of neutron flux Kz (section 5)	
PN AX6	axial non-uniformity of neutron flux Kz (section 6)	
PN AX7	axial non-uniformity of neutron flux Kz (section 7)	
PN AX8	axial non-uniformity of neutron flux Kz (section 8)	
PN AX9	axial non-uniformity of neutron flux Kz (section 9)	
RA11P02	Pressure before Main steam valve 1	
RA11S03	Turbine stop & regulating valves	
RA11T01	steam temperature before Main steam valve 1	
RA12P02	Pressure before Main steam valve 2	
RA12T01	steam temperature before Main steam valve 2	
RA13P02	Pressure before Main steam valve 3	
RA13T01	steam temperature before Main steam valve 3	
RA14P02	Pressure before Main steam valve 4	
RA14T01	steam temperature before Main steam valve 1	
RC11P01 (kgs/cm2)	Pressure in Main Steam Collector	
REACTIVITY	reactivity	
RL71F01	feedwater flow rate to SG-1	
RL71S02	position of feedwater regulator SG-1	
RL72F01	feedwater flow rate to SG-2	
RL72S02	position of feedwater regulator SG-2	
RL73F01	feedwater flow rate to SG-3	
RL73S02	position of feedwater regulator SG-3	
RL74F01	feedwater flow rate to SG-4	
RL74S02	position of feedwater regulator SG-4	
SORT CAS	fuel enrichment for monitoring FA	
T POWER (MW)	Reactor Thermal power	
TIKONTUR (C)	Primary circuit mean temperature	
T2KONTUR	mean temperature of secondary circuit	

List of items at the alarm panel for VVER-1000 Reactor Department Simulator

EP	Emergency protection – reactor scram (AZ)	
EP from CR EP from Control Room key by operator		
N > Setpoint	tpoint Neutron power is greater than setpoint	
dT s1 < 10	Margin up to boiling (saturation) in primary circuit is less than	
· · · · · · · · · · · · · · · · · · ·	10C	
P1 < 150 N > 75	Pressure in reactor is less than 150 atm, while neutron power is	
·····	greater than 75%	
L SG – 650	Level in SG is less than 650 mm	
P mss > 80	Pressure in main steam collector is greater than 80	
T < 10	Reactor period is less than 10 seconds	
dT s1-2 > 75	Difference of saturation temperatures between primary and	
	secondary circuits is greater than 75C	
P1 < 140	Pressure in reactor is less than 140 atm	
F < 46	Frequency in external electric network is less than 46 Hz	
P1 > 180	Pressure in reactor is greater than 180 atm	
< 2 ГЦН	Less than 2 MCPs are in operation	
T h.l. > 330	Temperature in hot leg is greater than 330C	
dP MCP < 2.5	Pressure drop at MCP is less than 2.5 atm	
L Press < 400	Level in Pressurizer is less than 400 mm	
PP-1	Preventive protection 1 (PZ-1)	
PP from CR	m CR PP from Control Room key by operator	
N > Setpoint	Neutron power is greater than setpoint2	
<u>T < 20</u>	T < 20	
P sg > 70	Pressure in SG is greater than 70 atm	
P1 > 172	Pressure in reactor is greater than 172 atm	
F < 49	Frequency in external electric network is less than 49 Hz	
T1 > 325	Temperature in hot leg is greater than 325C	
MCP trip	MCP trip	
TDFWP trip	Feedwater pump trip	
Generator trip	Generator trip	
PCR	Power level limiting regulator (ROM)	
N heat > Setpoint	Thermal power is greater than setpoint2	
MSV closed	Main steam valves are closed	
PP-2	Preventive protection 2 (PZ-2)	
N > Setpoint	Neutron power is greater than setpoint	
P1 > 165	Pressure in reactor is greater than 165 atm	
CR drop	Dropping of control rod (failure)	
AUU	Fast reducing of reactor power (URB)	
AUU from CR	AUU from Control Room key by operator	
2 MCP trip	Two MCP trip	
TDFWP trip	Feedwater pump trip	
Generator trip	Generator trip	

MSV closed	Main steam valves are closed	
рана баланананананананананананананананананана		
SG	Preventive protection 1 (PZ-1)	
L SG1 > 39.5	Level in Steam Generator 1 is greater than 39.5 mm	
L SG2 > 39.5	Level in Steam Generator 2 is greater than 39.5 mm	
L SG3 > 39.5	Level in Steam Generator 3 is greater than 39.5 mm	
L SG4 > 39.5	Level in Steam Generator 4 is greater than 39.5 mm	
L SG1 > 22	Level in Steam Generator 1 is greater than 22 mm	
L SG2 > 22	Level in Steam Generator 2 is greater than 22 mm	
L SG3 > 22	Level in Steam Generator 3 is greater than 22 mm	
L SG4 > 22	Level in Steam Generator 4 is greater than 22 mm	
MSIV1 closed	Main steam isolating valve 1 is closed	
MSIV2 closed	Main steam isolating valve 2 is closed	
MSIV3 closed	Main steam isolating valve 3 is closed	
MSIV4 closed	Main steam isolating valve 4 is closed	
MSSV SG1 opened	Main steam safety valve for SG1 is opened	
MSSV SG2 opened	Main steam safety valve for SG2 is opened	
MSSV SG3 opened	Main steam safety valve for SG3 is opened	
MSSV SG4 opened	Main steam safety valve for SG4 is opened	
P SG1 > 84	P SG1 > 84Pressure in Steam Generator 1 is greater than 84 atm	
P SG2 > 84	P SG2 > 84Pressure in Steam Generator 2 is greater than 84 atm	
P SG3 > 84	Pressure in Steam Generator 3 is greater than 84 atm	
P SG4 > 84	Pressure in Steam Generator 4 is greater than 84 atm	
L SG1 > 62	Level in Steam Generator 1 is greater than 62 mm	
↑A II C	Raising of radioactivity in secondary circuit	
MSC	Main Steam Collector	
P mss < 52	Pressure in MSC is less than 52 atm	
P mss < 56	Pressure in MSC is less than 56 atm	
P mss < 62	Pressure in MSC is less than 62 atm	
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10	Primary Circuit	
L Press < 500	Level in pressurizer less than 500 mm	
L TY20B01 > 1500	Level in the tank of organized leakages is greater than 1500 mm	
TK disbalance	Disbalance of feedwater flow and purging water flow	
- MSSV Press opened	Main safety steam valve of pressurizer is opened	