Updated National Action Plan upon Stress-Test Results

State Nuclear Regulatory Inspectorate of Ukraine

Kyiv
2017

INTRODUCTION

In June 2011, Ukraine joined the European initiative of conducting stress tests at nuclear power plants in EU member states and neighboring countries (Stress Test Declaration). The stress tests were performed at Ukrainian NPPs in compliance with the stress test specifications agreed by the European Commission and ENSREG (13 May 2011, Declaration of ENSREG, Annex 1: EU Stress Test Specifications). The stress tests were focused on:

- Zaporizhzhya NPP units 1-6 (WWER-1000/320) and dry spent nuclear fuel storage facility (DSF) located on the Zaporizhzhya NPP site;
- Rivne NPP units 1, 2 (WWER-440/213) and units 3, 4 (WWER-1000/320;
- South Ukraine NPP unit 1 (WWER-1000/302), unit 2 (WWER-1000/338) and unit 3 (WWER-1000/320);
- Khmelnitsky NPP units 1, 2 (WWER-1000/320;
- Chornobyl NPP units 1-3 (spent fuel pools) and interim spent fuel storage facility (ISF-1) located on the Chornobyl NPP site.

The State Nuclear Regulatory Inspectorate of Ukraine (SNRIU) submitted the National Report developed in line with ENSREG recommendations to the EU Stress Test Secretariat on 30 December 2011 to be peer reviewed further.

ENSREG set forth results from the peer review of stress tests for EU states and neighboring countries (Ukraine and Switzerland) in the summary peer review report and country-specific reports.

The peer review country report for Ukraine concluded that the National Report of Ukraine complied with the ENSREG specifications, provided sufficient information to understand the design basis for external natural events, and identified adequate measures to compensate for safety deficiencies revealed. In addition, it was pointed out that previously planned NPP safety improvements should be completed.

The summary EC documents developed upon the peer review of stress tests and approved by the EC on 3 October 2012 set forth recommendations for the SNRIU to monitor, in a systematic manner, implementation of the measures identified upon stress tests by the operating organization. Along with recommendations for the SNRIU, the EC documents also outline good practices revealed in the peer review process.

In order to monitor the implementation of safety improvements at Ukrainian NPPs identified in the stress test and peer review processes, the SNRIU Board convened on 20 November 2012 to hold an open meeting. The SNRIU Board identified additional safety improvements related to severe accident management to take into account peer review recommendations.

The National Action Plan was developed at the beginning of 2013 to implement recommendations of the peer review of stress tests at Ukrainian NPPs and to ensure that the operating organizations take safety improvements identified upon stress tests and the SNRIU efficiently monitors this process.

The ENSREG summary report upon results of the workshop held on 22-26 May 2013 to discuss national action plans (ENSREG National Action Plans Workshop. Summary Report) indicated the following conclusions on the National Action Plan of Ukraine:

- The National Action Plan of Ukraine complied with the ENSREG recommendations on the format of national action plans and covered all necessary aspects;
- There were no open issues or additional questions for Ukraine upon the workshop.

The National Action Plan of Ukraine (2013) was updated in compliance with the recommendations provided in the 'ENSREG Post-Fukushima National Action Plans Workshop 20-24 April 2015. Terms of Reference'.

It should be noted that the number of safety improvement measures did not change for operating NPPs and Chornobyl NPP in the updated National Action Plan; the scope of measures remained unchanged as well.

The updated National Action Plan (2015) specified the status and schedule for implementation of safety improvement measures.

In 2017, the National Action Plan was updated again; the number and scope of planned measures have not changed. The status and schedule for implementation of the measures have been specified.

Part I "Safety Improvement Measures" of the updated National Action Plan provides a list of measures identified by the National Action Plan upon Stress-Test Results (2013) for operating NPPs and Chornobyl NPP with renewed information on the status and schedule of measures.

Part II "Status of Safety Improvement Measures" of the updated National Action Plan presents more detailed information for each of the measures, namely: short description of the planned scope for implementation, status of implementation (more detailed information is provided for completed measures) and revised schedule.

It should be emphasized that the schedule for a series of safety improvement measures at operating NPPs that require substantial funding has been extended, taking into account the situation on the territory of Ukraine over the last year and the decision made by the operating organization to shut down the power units when their design-basis life expires in order to implement safety improvement measures needed to justify long-term operation.

The Annex to the updated National Action Plan contains the National Action Plan upon Stress-Test Results (2013).

ABBREVIATIONS

C(I)SIP	Comprehensive (Integrated) Safety Improvement Program for Ukrainian NPPs
ChNPP	State Specialized Enterprise 'Chornobyl NPP'
DG	Diesel Generator
EC	European Commission
ECR	Emergency Control Room
Energoatom	National Nuclear Operator 'Energoatom'
EOP	Emergency Operating Procedure
EU	European Union
IAEA	International Atomic Energy Agency
ISF	Interim Spent Fuel Storage Facility
KhNPP	Khmelnitsky Nuclear Power Plant
MCR	Main Control Room
NPP	Nuclear Power Plant
PAMS	Accident and Post-Accident Monitoring System
PAR	Passive Autocatalytic Hydrogen Recombiner
PSA	Probabilistic Safety Assessment
RNPP	Rivne Nuclear Power Plant
SAMG	Severe Accident Management Guideline
SFA	Spent Fuel Assembly
SFP	Spent Fuel Pool
SG	Steam Generator
SSE	Safe Shutdown Earthquake
SUNPP	South Ukraine Nuclear Power Plant
UARMS	Unified State Automated Radiation Monitoring System in Ukraine
VS	Ventilation Stack
WWER	Water-Cooled Water-Moderated Power Reactor
ZNPP	Zaporizhzhya Nuclear Power Plant

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Part I. Safety Improvement Measures

Table 1.1 Measures Identified upon Stress Tests at Operating NPPs

No.	Measure / activity	Recommendations at European level	Recommendations at national level	Schedule/Status		
				[1]WWER-440/213	[2]WWER-1000/320	[3]WWER-1000/302, 338
	Natural Hazards					
1.	Equipment qualification (harsh environments and seismic* impacts)	(5), (6), (11), (13)	[1], [2]	completed/ completed	completed/ 2020 ongoing	completed/ completed
2.	Seismic resistance of structures, systems and components important to safety	(5)	[1], [2]	2020/2020 ongoing	2020/2020 ongoing	completed/ completed
3.	Consideration of a full range of initiating events for all reactor and SFP states in PSA	(5)	[1], [2]	completed/ completed	completed/ 2020 ongoing	completed/ completed
4.	Implementation of a seismic monitoring system at NPP sites	(10)	[1], [2]	SUNPP – 2012/completed ZNPP -2020 /ongoing RNPP - 2017/completed KhNPP - 2019/ongoing		
	Loss of Safety Systems (Loss of Power and/or Ultimate Heat Sink)					
5.	SFP makeup and cooling in long-term station blackout conditions	(14), (17), (23), (24), (26), (27), (28)	[1], [2]	completed/ completed	completed/ 2019 ongoing	completed/ completed
6.	SG makeup and cooling in long-term station blackout conditions	(14), (17), (24), (26), (27), (28)	[1], [2]	completed/ completed	completed/ 2019 ongoing	completed/ completed
7.	Improved reliability of emergency power supply	(15), (16), (17), (18), (22), (24),	[1], [2]	–	–	completed/ completed

[1] RNPP unit 1/unit 2

[2] Pilot unit (ZNPP-1) / final period for implementation of the measures at all power units of this design.

According to national safety regulations, a measure is first implemented at the pilot power units with reactors of each design and then at other units taking into account the pilot experience

[3] SUNPP unit 1/unit 2

No.	Measure / activity	Recommendations at European level	Recommendations at national level	Schedule/Status		
				[1]WWER-440/213	[2]WWER-1000/320	[3]WWER-1000/302, 338
		(26), (27), (28)				
8.	Emergency power supply in long-term loss of power	(15), (16), (17), (18), (22), (24), (26), (27), (28)	[1], [2]	2019/2018 ongoing	completed/ 2019 ongoing	–
9.	Functionality of group A equipment fed from the service water system in case of water discharge in spray ponds	(17), (24), (26), (27), (28)	[1], [2]	2018/ completed	completed/ 2019 ongoing	–
10.	Functionality of group A equipment fed from the service water system in case of failure of ventilation cooling towers and/or service water supply pumps	(17), (24), (26), (27), (28)	[1], [2]	–	–	completed/ completed
11.	Provision of instrumentation during and after accidents (accident and post-accident monitoring system)	(18)	[1], [2]	2018/2018 ongoing	completed/ 2019 ongoing	2018/2019 ongoing
12.	Development, technical justification, validation and implementation of symptom-oriented EOPs for management of design-basis and beyond design-basis accidents (low power and shutdown states)	(19), (23)	[1], [2]	completed/ completed	completed/ completed	completed/ completed
13.	Detailed analysis of primary system makeup in case of loss of power and/or ultimate heat sink	(20)	[1], [1]	completed	2019 ongoing	2019 ongoing
14.	Replacement of self-contained air conditioners by those qualified for harsh environments and seismic impacts	(22)	[1], [2]	completed/ completed	completed/ 2020 ongoing	completed/ completed
15.	Habitability of MCR and ECR in design-basis and beyond design-basis accidents (installation of iodine filters)	(22)	[1], [2]	completed	–	–
Severe Accident Management						
16.	Severe accident analysis. SAMG development	(39), (41)	[1], [2]	completed/ completed	completed/ completed	completed/ completed
17.	Prevention of early containment bypassing in case of molten corium spread to the containment	(31), (32)	[1], [2], [1]	–	completed/ 2020 ongoing	completed
18.	Implementation of a containment hydrogen control system for beyond design-basis accidents	(31), (32), (41), (11)	[1], [2]	completed	2018/2020 ongoing	completed/ 2019

No.	Measure / activity	Recommendations at European level	Recommendations at national level	Schedule/Status		
				[1]WWER-440/213	[2]WWER-1000/320	[3]WWER-1000/302, 338
						ongoing
19.	Development and implementation of hydrogen mitigation measures for beyond design-basis accidents	(31), (32), (41)	[1], [2]	2020/2020 ongoing	completed/ 2019 ongoing	completed/ completed
20.	Implementation of a containment venting system	(31), (32), (41)	[1], [2]	2020/2020 ongoing	2018/2020 ongoing	2018/2018 ongoing
21.	Analysis of the strategy for possible corium confinement within the reactor pressure vessel	(31), (32)	[1], [1]	completed	2020 ongoing	2020 ongoing
22.	Analysis of the need and possibility to qualify power unit components that may be involved in severe accident management for harsh environments	(31), (32), (33)	[1], [1]	2020 ongoing	2020 ongoing	2020 ongoing
23.	Detailed analysis and development of conceptual decisions on management with large volumes of contaminated water	(42)		2019 ongoing	2019 ongoing	2019 ongoing
24.	Seismic evaluation of buildings and systems of the on-site emergency center and their robustness in severe accident conditions	(43), (44)		SUNPP - completed ZNPP, RNPP, KhNPP - 2018/planned		
25.	Analysis of severe accident phenomena based on available experimental data and improvement of computer models	(44)	(5)	2019 planned	2019 planned	2019 planned
Additional Topics and Activities						
26.	Harmonization of Ukrainian nuclear and radiation safety regulations with WENRA reference levels: a) self-assessment; b) development of a harmonization action plan	(31)		completed		
27.	Self-assessment of the nuclear safety regulation system using the new IAEA instrument – SARIS	(103)		completed		
28.	Provision of mobile laboratories to ZNPP and SUNPP	(110)		SUNPP – completed. ZNPP – 2020		
29.	Development of the concept and plan for the unified state automated radiation monitoring system of Ukraine (UARMS)	(110), (114), (120)		ongoing		
30.	Long-term (more than 24 hours) emergency training for all response parties, including central executive authorities, to test the knowledge transfer procedure in conditions of shift work of	(113)		conducted annually		

No.	Measure / activity	Recommendations at European level	Recommendations at national level	Schedule/Status		
				[1]WWER-440/213	[2]WWER-1000/320	[3]WWER-1000/302, 338
	emergency staff					
31.	Implementation of the RODOS system	(115)		2017 completed		
32.	Modernization of the SNRIU Emergency Response and Information Centre	(121)		2017 completed		

Table 1.2 Measures Identified upon Stress Tests at Chornobyl NPP

No.	Measure / activity	Recommendations at European level	Recommendations at national level	Status	Schedule
1.	Installation of an additional level control device in 1 (2) fuel assembly cooling pools-1, 2 for emergencies related to level water decrease below marks 19, 22	(18)	[3], [4]	completed	2012
2.	Calculation analysis of buildings of nuclear safety category 1 to determine safety margins and potential failures under loads induced by a tornado of class F 3.0	(13)	[3], [4]	completed	2016
3.	Calculation analysis of buildings of nuclear safety category 1 to determine safety margins and potential failures under seismic loads	(13)	[3], [4]	completed	2015
4.	Seismic resistance analysis of ISF-1 SFP lining	(23), (30)	[3], [4]	completed	2015
5.	Analysis of stability and potential failures of VS-1 under SSE and tornado	(23), (30)	[3], [4]	completed	2014
6.	Nuclear safety justification for the spent fuel pools of units 1, 2 with 250×110 mm arrangement of SFAs (as reserve for one ISF-1 compartment)	(23), (30)	[3], [4]	completed	2012
7.	Justifying calculation of the maximum fuel cladding temperature taking into account potential radiological consequences from wet SFA storage	(23), (30)	[3], [4]	completed	2013
8.	Development of an action plan to improve the emergency preparedness system in case of beyond design-basis accidents caused by natural hazards, including emergency response measures in case of damage of the building and leakage of SFP	(26), (28), (34), (38), (39)	[3], [4]	completed	2012
9.	Amendment of the ChNPP accident and emergency response plan (32P-S) to improve emergency preparedness	(26), (28), (34), (37), (39)	[3], [4]	completed	2012
10.	Development of measures on prompt access of emergency teams from Slavutych by alternative routes in case of damage of Slavutych–ChNPP railroad tracks caused by SSE	(34)	[3], [4]	completed	2012
11.	Modernization of the ISF-1 radiation monitoring system to ensure neutron flux density monitoring	(18), (30)	[3], [4]	completed	2012
12.	Additional radiation monitoring of exposure dose rate of the container car in ISF-1 during spent fuel transport	(18)	[3], [4]	completed	2012
13.	Replacement of the UDZhG-04R detector with an RWM-02 detector for the instrumentation channel for monitoring the activity concentration of service water after heat exchangers in ISF-1 spent fuel pools	(18)	[3], [4]	completed	2013
14.	Power supply to ISF-1 essential equipment fed from mobile DG	(15), (16), (26)	[3], [4]	completed	-
15.	Purchase of a new container car for SFA transport	(30)	[3], [4]	ongoing	2018

No.	Measure / activity	Recommendations at European level	Recommendations at national level	Status	Schedule
16.	Revision of the ISF-1 safety improvement plan	(23), (30)	[3], [4]	completed	2012
17.	Introduction of the topic “multiple failures of regular systems and equipment in severe weather conditions” into the 2012 training program for ChNPP staff of certain positions for detailed theoretical elaboration of the training scenario	(26), (28), (34), (108)	[3], [4]	completed	2012
18.	Introduction of the topic “multiple failures of regular systems and equipment in severe weather conditions” into the 2012 training program (Section 14) for practical exercise by staff of all shifts	(26), (28), (34), (108)	[3], [4]	completed	2012
19.	Psychological training of staff intended to increase resilience to psychological stress, develop self-control, composure and promote mutual aid and cooperation	(38), (122)	[3], [4]	completed	2012
20.	Implementation of a system for psychological selection and training of individuals involved in severe accident management, similar to the system for selection of operating personnel	(38)	[3], [4]	completed	2012

References

1. Comprehensive (Integrated) Safety Improvement Program (C(I)SIP), approved by Cabinet Resolution No. 1270 dated 7 December 2011.
2. SNRIU Board Resolution No. 13 dated 24-25 November 2011 “On results of the targeted safety reassessment of operating NPPs and ZNPP dry spent fuel storage facility in the light of the events at Fukushima-1”.
3. SNRIU Board Resolution No. 12 dated 3 November 2011 “On result of the targeted safety reassessment of Chornobyl NPP units 1-3 and Interim Spent Nuclear Fuel Storage Facility in the light of the events at Fukushima-1”.
4. Safety Improvement Plan for ChNPP Nuclear Installations.
5. SNRIU Board Resolution No. 14 dated 20 November 2012 “On the progress in implementation of measures based on stress-tests results for operating NPPs”.

Part II. Status of Safety Improvement Measures

Section 1. Status of Measures Identified upon Stress Tests at Operating NPPs

This Section provides information on the status of measures identified upon stress tests at operating NPPs and presented in Table 1.1 of Part IV "Plan for Implementation of Safety Improvements" of the National Action Plan upon Stress-Test Results (2013).

Area: Natural Hazards

Item 1. Equipment qualification (harsh environments and seismic impacts)*
This measure is intended to confirm the operability of NPP systems and components and their capability to perform safety functions under seismic events and harsh environments (high temperature, pressure, radiation, moisture etc.) that may occur in design-basis accidents. Nonqualified equipment has to be replaced or necessary compensatory measures are to be implemented.

The input data for equipment qualification for all NPP units have been agreed by the SNRIU.
SUNPP-1,2,3, RNPP-1, 2, 3, ZNPP-1,2: measure has been completed.
RNPP-4: qualification for harsh environments has been completed; activities to increase seismic qualification are ongoing.
ZNPP-3: qualification for harsh environments has been completed; activities to increase seismic qualification are ongoing.
ZNPP-4: assessment of current status of qualification for harsh environments and seismic impacts is ongoing.
KhNPP-1,2: assessment of current status of qualification for harsh environments and seismic impacts has been completed; activities to increase qualification are ongoing.
Schedule: ZNPP-3,4, RNPP-4 and KhNPP-1 – 2018; other power units – 2020.

Item 2. Seismic resistance of structures, systems and components important to safety
This measure is intended to ensure resistance to earthquakes of at least 7 magnitudes on the MSK-64 scale (but not less than 0.1 g peak ground acceleration) for equipment, piping, buildings and structures required to perform critical safety functions (provide for safe reactor shutdown and keep the reactor in safe state, remove heat from the reactor core and spent fuel pool, prevent radioactive releases to the environment).

The input data for assessing the seismic resistance of equipment, piping, buildings and structures of all NPP units have been agreed by the SNRIU.
SUNPP-1,2, ZNPP-3: measure has been completed.
SUNPP-3: seismic resistance of buildings and structures has been assessed; assessment of seismic resistance of equipment and piping considering compensatory measures (replacement, reinforcement) is in the final stage.
RNPP-1-4: seismic resistance of buildings and structures has been assessed; assessment of seismic resistance of equipment and piping considering compensatory measures (replacement, reinforcement) is ongoing.
ZNPP-1-2: seismic resistance of equipment, piping, buildings and structures has been assessed; compensatory measures (replacement, reinforcement) are ongoing.
ZNPP-4: seismic resistance of buildings and structures has been assessed; assessment of seismic resistance of equipment and piping is ongoing.
ZNPP-5, 6: assessment of seismic resistance of components and structures considering compensatory measures (replacement, reinforcement) is ongoing.
ZNPP-5, 6, KhNPP-1, 2: seismic resistance of equipment, piping, buildings and structures considering compensatory measures (replacement, reinforcement) is ongoing.

Schedule: SUNPP-3 – 2018; other WWER-1000 units and RNPP-1,2 – 2020.

Item 3. Consideration of a full range of initiating events for all reactor and SFP states in PSA
This measure is intended to perform probabilistic safety assessments of levels 1 and 2 for a full range of initiating events (including natural hazards) for all regulated states of the power unit, covering both the reactor core and spent fuel pool.

SUNPP-1, 2, 3, ZNPP-1,2,3, 4, RNPP-3,4, KhNPP-2: measure has been completed. RNPP-1,2: measure has been completed, the report is at the SNRIU for agreement.
Schedule for other power units – 2018 – 2020.

Item 4. Implementation of a seismic monitoring system at NPP sites
This measure is intended to implement systems for continuous seismic monitoring in order to determine actual seismic characteristics of NPP sites. The monitoring results and numerical parameters for predicted seismic events will be used to plot new accelerograms and obtain ground response spectra for the design-basis earthquake (DBE) and safe shutdown earthquake (SSE).

SUNPP site: measure has been completed (on-site seismic monitoring system was commissioned in 2012). According to seismic monitoring, the assessed seismic resistance is not required to be corrected.
RNPP: measure has been completed. The on-site seismic monitoring system was installed and commissioned in mid-2015; surveys were conducted during two years. Seismic surveys are ongoing.
ZNPP: on-site seismic monitoring system has been installed and is being commissioned. The results of seismic monitoring are to be obtained in 2020.
KhNPP: equipment purchase procedure is underway.
Schedule for measure completion – 2019.

Area: Loss of Safety Systems (Loss of Power and/or Ultimate Heat Sink)

Item 5. SFP makeup and cooling in long-term station blackout conditions
This measure is intended to ensure SFP emergency makeup through a series of actions to connect a mobile pumping unit to restore forced water circulation in SFP with boric acid solution from tanks and emergency makeup of SFP from on-site water supply sources. It is needed to:

- perform calculations to justify characteristics of the mobile pumping unit (MPU) to ensure SFP makeup during the time required to restore design-basis systems;
- supply equipment;
- install special-type connectors to enable connection of MPU hydrants to on-site water supply sources and pressure piping of the SFP cooldown system and/or piping of emergency SFP makeup from the spray system;
- develop and introduce emergency procedures for use and connection of MPUs.

The concept for implementation of this measure for all power unit designs was developed by the operating organization and agreed by the SNRIU; pilot power units are RNPP-2, SUNPP-1 and ZNPP-1.
ZNPP-1,2,3, RNPP-1,2,3, SUNPP-1,2: measure has been completed.
RNPP-4: measure has been completed partially; MPU has been supplied; measure is to be completed in 2018.
Schedule: SUNPP-3, ZNPP-4,5, RNPP-4 – 2018; other power units – 2019.

Item 6. SG makeup and cooling in long-term station blackout conditions
This measure is intended to connect mobile units to supply feedwater to SG and requires to:

- analyze potential water discharge to SG from turbine compartment deaerators at the maximum flow rate in long-term station blackout conditions;
- supply equipment;

- take actions to connect MPU for emergency SG makeup from on-site water sources, including:
  - calculations to justify MPU characteristics;
  - installation of special-type connectors to enable connection of MPU to any on-site water source and to the pressure side of the SG emergency makeup system;
  - development and implementation of emergency procedures for use of MPU for SG makeup and emergency heat removal from the core through SG.

Potential recriticality and coolant leak through the main coolant pump sealing shall be taken into account in implementation of the measure.

The concept for implementation of this measure for all power unit designs was developed by the operating organization and agreed by the SNRIU; pilot power units are RNPP-2, SUNPP-1 and ZNPP-1.
ZNPP-1,2,3, SUNPP-1,2, RNPP-3, RNPP-1,2: measure has been completed
Schedule: ZNPP-4,5, RNPP-4, KhNPP-1,2, SUNPP-3 – 2018; ZNPP-6 – 2019.

Item 7. Improved reliability of emergency power supply (SUNPP-1,2)
Item 8. Emergency power supply in long-term loss of power (other power units
This measure is intended to take a series of actions to connect a mobile diesel generator to recover power supply to systems that can be used to inject water to the primary side and spent fuel pools, as well as to monitor and perform critical safety functions, ensure remote control of valves and emergency lighting, including:

- calculations to justify characteristics of the mobile diesel generator;
- equipment supply;
- connection of the mobile diesel generator to buses of the emergency power supply system of category 1 to energize design-basis pumps for high-pressure emergency boron injection, SFP cooldown pumps, uninterruptible power supply sources and systems required for monitoring of emergency processes;
- development and implementation of emergency procedures for use of the mobile diesel generator.

The concept for implementation of this measure for all power unit designs was developed by the operating organization and agreed by the SNRIU; pilot power units are RNPP-2, SUNPP-1 and ZNPP-1.
SUNPP-1,2: measure has been completed (MDG-0.4 kV diesel generator unit located on a special truck platform was purchased, including: 800 kW diesel generator, distribution cabinet with feeder breakers, 0.4/0.23 kV distribution transformers for 200 kVA and power cables; a special site for MDG was arranged; connection places were determined; operating documentation for MDG-0.4 kV was developed and existing documentation was amended; tests were performed).
ZNPP-2,4: measure has been completed partially (MDG-0.4 kV mobile diesel generators have been purchased and connected on a temporary basis to safety system buses). The measure is to be completed for ZNPP-2,4 in 2018.
ZNPP-1, 3: measure has been completed (MDG-0.4 kV mobile diesel generator has been purchased and connected to safety system buses).
Schedule: RNPP-2,3,4, ZNPP-5 – 2018; RNPP-1, ZNPP-6

Item 9. Functionality of group A equipment fed from the service water system in case of water discharge in spray ponds
This measure is intended to take a series of actions for emergency supply of service water to essential loads by a mobile pumping unit from the NPP circulation water cooling system or other available water sources including:

- determination of an optimal list of loads that require emergency supply of service water from the mobile pumping unit (MPU);
- calculation to justify MPU characteristics to ensure water supply within the period required to restore operation of design-basis systems;

- equipment supply;
- development and implementation of emergency procedures for MPU use and connection.

The concept for implementation of this measure for WWER-440/213 and WWER-100/320 units was developed by the operating organization and agreed by the SNRIU; pilot power units are RNPP-2 and ZNPP-1.
ZNPP-1,2,3, RNPP-2, 3: measure has been completed
Schedule: RNPP-1, 4, ZNPP-4-5, KhNPP-2, SUNPP-3 – 2018. ZNPP-6, KhNPP-1 – 2019.
This measure is not envisaged for SUNPP units 1, 2 (WWER-1000/302, 338) since their design includes ventilation cooling towers instead of spray ponds.

Item 10. Functionality of group A equipment fed from the service water system in case of failure of ventilation cooling towers and/or service water supply pumps
This measure is intended to take a series of actions to provide cooling water to standby DGs, equipment and mechanisms needed for reactor cooldown in loss of normal power supply buses and failure of essential service water supply system.

The concept for implementation of this measure for WWER-1000/302, 338 was developed by the operating organization and agreed by the SNRIU. The pilot power unit is SUNPP-1.
SUNPP-1,2: measure has been completed (HRC-110 pumping station was purchased, necessary installation actions were taken, operating documentation was amended, testing was performed, procedure for alternative water supply from MPU to essential loads (with water intake from two possible sources: water intake pools of ventilation cooling towers or off-take/intake recirculation water channel of the Tashlyk reservoir) was developed, personnel were trained).

Item 11. Provision of instrumentation during and after accidents (accident and post-accident monitoring system)
This measure is intended to:
- install features to monitor coolant overheating at fuel assembly outlet, under the reactor head assembly and in hot legs of reactor coolant piping within an extended temperature range, including overheating modes;
- introduce features to monitor coolant level above the core in emergencies;
- install features to monitor hydrogen concentration in the containment during accidents;
- conduct additional analysis to determine the minimum required list of signals for accident and post-accident reactor monitoring;
- introduce emergency instrumentation with an extended measurement range for monitored process parameters;
- introduce a data storage system for conditions of design-basis and beyond design-basis accidents (black box).

RNPP-1,2 (WWER-440): The concept for implementation of this measure was developed by the operating organization and agreed by the SNRIU, technical specifications for equipment supply are under development.
Schedule – 2018.
WWER-1000 power units: The concept for implementation of this measure was developed by the operating organization and agreed by the SNRIU; SUNPP-1 and ZNPP-1 are pilot units. Technical specifications for equipment supply were developed and agreed with the SNRIU.
ZNPP-1,2: measure has been completed; PAMS has been commissioned.
Schedule: SUNPP-1, RNPP-1,2, ZNPP-4 , RNPP-3,4 – 2018, other power units – 2019 .

Item 12. Development, technical justification, validation and implementation of symptom-oriented EOPs for management of design-basis and beyond design-basis accidents (low power and shutdown states)

Measure has been completed for Ukrainian NPPs (symptom-based EOPs for low power and shutdown states have been developed and implemented).

Item 13. Detailed analysis of primary system makeup in case of loss of power and/or ultimate heat sink
This measure is intended to carry out a detailed and comprehensive analysis of the need for makeup of the primary system in case of accidents involving loss of power supply and/or ultimate heat sink. The analysis is to address potential accident progression scenarios in which loss of power and cooling water will make primary system makeup impossible. Hence, the use of mobile sources for primary system makeup shall be considered as a compensatory measure. Upon results of the analysis, additional measures for primary system makeup shall be revised as appropriate and additional technical features shall be determined.

WWER-440/213: measure was completed in 2016.

WWER-1000/320 and WWER-1000/302, 338: measure is ongoing; detailed analysis of the need for primary system makeup for power units (SUNPP-1 and ZNPP-1) in case of accidents involving loss of power and/or ultimate heat sink will be carried out by the Scientific and Technical Center. Schedule for submission of analysis results to the SNRIU – 2018.

Item 14. Replacement of self-contained air conditioners by those qualified for harsh environments and seismic impacts
KhNPP-1,2 and RNPP-4: measure was completed long before approval of the National Action Plan (as part of post-commissioning measures for KhNPP-2 and RNPP-4).
ZNPP-1, 3, SUNPP-1,2,3, RNPP-1,2: measure has been completed
Schedule: ZNPP-4,5, RNPP-3 - 2018; ZNPP-2 – 2019; ZNPP-6 – 2020.

Item 15. Habitability of MCR and ECR in design-basis and beyond design-basis accidents (installation of iodine filters)
This measure was intended only for WWER-440/213 power units.
The measure was completed (2011 – RNPP-1; 2012 – RNPP-2).

Area: Severe Accident Management

Item 16. Severe accident analysis. SAMG development
This measure is intended to develop severe accident management guidelines for operation at rated power as well as for low power and shutdown states. The guidelines shall be aimed at severe accident management both in the reactor core and spent fuel pool.
The measure has been completed.

Item 17. Prevention of early containment bypassing in case of molten corium spread to the containment
SUNPP-1,2: measure has been completed (appropriate analytical justifications were developed, enclosing concrete structure was installed on the way of potential corium spread, operating documentation was amended, in particular, regarding the position of doors in the lower part of the reactor concrete vault and in the room for reactor pressure vessel inspection during operation (closed doors are needed for shielding but they must not be locked to hinder spreading of the main corium part in case of an accident).
WWER-1000/320 units: measure has been completed at ZNPP-1, 3.
Schedule: ZNPP-2,4, RNPP-3 – 2018; ZNPP-5, RNPP-4, KhNPP-1,2, SUNPP-3 – 2019; ZNPP-6 – 2020.

Item 18. Implementation of a containment hydrogen control system for beyond design-basis accidents
This measure is intended to implement a hydrogen control system in the containment to ensure continuous monitoring and recording of hydrogen concentration (including post-accident period), which

shall comply with qualification requirements for operation during design-basis and beyond design-basis accidents with loss of primary coolant and under seismic events.

SUNPP-1 and RNPP-1,2: measure has been completed (system was installed, operating documentation was amended, operating procedure for the system was developed, personnel were trained).
Schedule: ZNPP-1,2, 4, RNPP-3,4 – 2018; ZNPP-3,5, KhNPP-1,2, SUNPP-2,3 – 2019; ZNPP-6 – 2020.

Item 19. Development and implementation of hydrogen mitigation measures for beyond design-basis accidents

This measure is intended to install passive autocatalytic hydrogen recombiners in the containment for safe mitigation of hydrogen during design-basis and beyond design-basis accidents leading to severe core damage.

SUNPP-1,2, ZNPP-1,2,3: measure has been completed (qualitative and quantitative analysis of hydrogen generation and spread was carried out, the number and locations of PARs were justified, PARs were tested on factory site, PARs were installed at the power unit, operating documentation was amended).

RNPP-3,4 and KhNPP-2: measure has been completed partially (PARs were installed without catalysts). The measure is to be completed in 2018.
Schedule: ZNPP-4,5, SUNPP-3– 2018; ZNPP-6, KhNPP-1 – 2019; RNPP-1, 2 – 2020.

Item 20. Implementation of a containment venting system

This measure is intended to:

- develop and implement a technical decision on forced filtered containment venting;
- supply and install equipment;
- develop a procedure for emergency containment venting in case of a severe accident, amend severe accident management guidelines.

In development of the system design, it is necessary to:

- perform appropriate calculations to confirm the effectiveness of containment pressure decrease, effectiveness of filtration of the vented medium, taking into account the need to minimize radioactive contamination of the environment;
- ensure that the system remains operational in station blackout conditions.

The concept for implementation of this measure was developed by the operating organization and agreed by the SNRIU; pilot power units are RNPP-1, SUNPP-1 and ZNPP-1.
SUNPP-1,2, ZNPP-1,2,3: first stage was completed (analytical and technical justification was provided for containment venting through existing exhaust air ducts and further release of the steam-gas medium to atmosphere through the ventilation stack and treatment on available iodine and airborne filters, piping made of steel sheets was replaced by steel seamless piping, necessary installation work was performed). Second stage is underway (purchase of equipment for filtered venting). The second stage is to be implemented for SUNPP-1,2 in 2018, ZNPP-1 in 2018 and ZNPP-2,3 in 2019.
The first stage is implemented at RNPP-3 in scheduled outage-2017 and the second stage is to be completed in 2019.
Schedule: ZNPP-4,5, RNPP-3, SUNPP-3 – 2019; other power units – 2020.

Item 21. Analysis of the strategy for possible corium confinement within the reactor pressure vessel

This measure is intended to analyze the possibility to implement the strategy for corium confinement within the reactor pressure vessel during severe accidents. The analysis shall take into account:

- need to avoid the occurrence of criticality in the corium;
- need for additional measures to prevent early containment bypassing;
- experience and advances of design organizations in countries operating WWER NPPs.

RNPP-1,2 (WWER-440/213): measure has been completed.

WWER-1000/302, 338, 320: schedule – 2020.

Item 22. Analysis of the need and possibility to qualify power unit components that may be involved in severe accident management for harsh environments

The measure is implemented in stages: a list of equipment that may be involved in severe accident management is developed at the first stage in compliance with the approaches agreed by the SNRIU (ongoing). At the second stage, in compliance with the list of equipment involved in severe accident management agreed with the SNRIU, equipment will be qualified to check its functionality in conditions that may occur in severe accidents for protection of the containment (after implementation of the measure on corium confinement in the reactor pressure vessel).

Schedules for completion:

Stage 1 – 2018;

Stage 2 – after implementation of measures on corium confinement in the reactor pressure vessel – 2020.

Item 23. Detailed analysis and development of conceptual decisions on management with large volumes of contaminated water

Energoatom developed a scientific and technical report on this topic in 2016. In 2017, SSTC NRS reviewed the report on application of the proposed approaches and calculations to determine the amount and specific activity of water that may result from a beyond design-basis accident. Based on the review, the operating organization was provided with recommendations on further analyses on this topic and performance of the calculations to develop a conceptual technical decision on management of large volumes of radioactive waste and submit this technical decision to the SNRIU for agreement.

Schedule: 2019.

Item 24. Seismic evaluation of buildings and systems of the on-site emergency center and their robustness in severe accident conditions

SUNPP site: measure has been completed (seismic resistance at a level of 0.15g for structures of the central control room and 0.18g for the on-site emergency center is provided, habitability of the center in severe accident conditions is ensured).

ZNPP, RNPP and KhNPP sites: measure is to be completed in 2018.

SNRIU Order “On Amendment of Requirements for the On-site and Off-site Emergency Centers” No. 201 of 9 December 2016, registered in the Ministry of Justice of Ukraine on 28 December 2016 by No. 1725/29855, requirements were established for location of the on-site and off-site emergency centers “so that emergency response processes can be controlled on the NPP site if infrastructure is damaged in close vicinity to the plant as a result of low-level internal events, external events and/or their combination” and the following basic safety conditions are met: … “confirmation of seismic resistance of structures and equipment of the NPP emergency center in safe shutdown earthquake”.

In accordance with Section I para. 6 of these Requirements, “the schedule and scope of activities to bring the NPP emergency centers that are under operation, construction, upgrading or design into compliance with these Requirements are established and justified by the operating organization upon agreement with the State Nuclear Regulatory Inspectorate of Ukraine”.

Item 25. Analysis of severe accident phenomena based on available experimental data and improvement of computer models

The first stage of this measure has been completed: Program for Analysis of Severe Accident Phenomena Based on Available Experimental Data and Improvement of Computer Models has been developed and agreed by the SNRIU. The Program identifies further administrative and technical actions to:

- validate and improve computer models for analysis of severe accidents (including purchase of new up-to-date computer codes);
- analyze severe accident phenomena with a high degree of uncertainty and assumptions made in the development of severe accident management guidelines.

Schedule for Program implementation – 2018-2019.

Additional Topics and Activities

Item 26. Harmonization of Ukrainian nuclear and radiation safety regulations with WENRA reference levels:

a) self-assessment;

b) development of a harmonization action plan

In order to implement this measure, the SNRIU:

- carried out self-assessment for compliance of national nuclear safety regulations with the "WENRA Reactor Safety Reference Levels 2008" in the framework of a EC technical assistance project and conducted peer review of the self-assessment involving experts from regulatory authorities of Czech Republic, Slovakia, Finland and Bulgaria;
- "WENRA Safety Reference Levels for Existing Reactors. Update in relation to lessons learned from TEPCO Fukushima Dai-ichi accident" in the framework of activities along will all WENRA member states and conducted respective peer reviews.

The results of these activities are reflected by the SNRIU in annual rule-making plans agreed by the SNRIU.

Item 27. Self-assessment of the nuclear safety regulation system using the new IAEA instrument – SARIS

Self-assessment of the nuclear safety regulation system using the new IAEA instrument SARIS is carried out by the SNRIU on a systematic basis: persons responsible for different regulatory areas are appointed, questionnaires are updated in the light of new IAEA publications. In particular, results of self-assessment in the emergency preparedness and response area for compliance with IAEA GSR Part 7 will be used in review of the national plan of response to nuclear and radiation accidents planned for 2018.

Item 28. Provision of mobile laboratories to ZNPP and SUNPP

SUNPP site: two mobile radiological monitoring laboratories based on off-terrain vehicles were purchased and supplied in 2012; trial operation stage is ongoing.

ZNPP site: activities are ongoing in the framework of C(I)SIP measure 14401 (ARMS) with deadline of 2020.

Item 29. Development of the concept and plan for the unified state automated radiation monitoring system of Ukraine (UARMS)

This measure is implemented to comply with the Cabinet Resolution "On Approval of the Action Plan for Development of a Unified Automated Radiation Monitoring System by 2015" to ensure radiation safety and radiation monitoring based on automated collection, transfer and analysis of actual data on radiation situation on the territory of Ukraine as well as to predict the development of radiation situation to support activities of state authorities at all levels and assess transboundary transfer of radioactivity inside and outside the country.

The draft UARMS concept was developed, its interdepartmental discussion took place, but it was not approved and other measures of the above-mentioned Action Plan were not implemented because of administrative changes in the structure of executive bodies; in particular, the Ministry of Emergencies and State Health and Epidemiological Service were liquidated, subordination of the State Agency of Ukraine on Exclusion Zone Management changed, a new structure, State Service of Ukraine for Food Safety and Consumer Protection, was established, etc.

Functions of the state system of environmental radiation monitoring are performed by hydrometeorological posts of the Ukrainian Hydrometeorological Center of the State Emergency Service of Ukraine, whose activities are coordinated by the Minister of Internal Affairs of Ukraine.
In the framework of European Commission projects, a forecasting center was established at the Ukrainian Hydrometeorological Center. This center uses numerical weather forecasts and JRODOS automated decision support system. Since 2016, the Ukrainian Hydrometeorological Center transmits data from Ukraine on the gamma dose rate to the European Radiological Data Exchange Platform EURDEP.
Information can be found at https://remap.jrc.ec.europa.eu/GammaDoseRates.aspx

Item 30. Long-term (more than 24 hours) emergency training for all response parties, including central executive authorities, to test the knowledge transfer procedure in conditions of shift work of emergency staff
These long-term exercises are conducted in Ukraine annually at one of the NPPs in compliance with the schedule agreed by the SNRIU. For example, full-scale training at Khmelnitsky NPP was conducted from 31 May to 2 June 2016 to test interaction plans in case of diversions and the NPP emergency plan, involving participation and interaction of protection, security, defense and response forces at different levels. On 4-5 October 2017, training at Rivne NPP was conducted on a conditional accident scenario including a combination of external events. In addition, with support of the Defense Threat Reduction Agency of the U.S. Department of Defense, command and staff exercises were conducted to test interaction between response forces at the regional level at South Ukraine NPP in December 2016 and command and staff exercises were conducted at the state level on a conditional accident scenario at Zaporizhzhya NPP on 5-7 September 2017.

Item 31. Implementation of the RODOS system
On 30 2016, the RODOS decision support system was officially presented in Ukraine at the State Emergency Service of Ukraine with participation of representatives from the European Commission, SNRIU, Energoatom Company, National Academy of Sciences of Ukraine and other agencies.

http://www.kmu.gov.ua/control/uk/publish/article?art_id=249152554&cat_id=249891310

http://mvs.gov.ua/ua/news/1750_V_DSNS_vidbulasya_prezentaciya_sistemi_RODOS_Ukraina_VIDEO.htm

http://www.nas.gov.ua/UA/Messages/news/Pages/View.aspx?MessageID=2407

The RODOS decision support system in Ukraine was checked and verified with results of other countries during the international IAEA ConvEx-3 emergency exercises based on a scenario of a conditional accident at Paks NPP (Hungary) on 21-22 June 2017.
The RODOS decision support system was used for prediction and assessment of releases, including those in transboundary context, during full-scope exercises at RNPP (3-4 October 2017) and command and staff exercises of state level using a conditional accident at ZNPP (5-7 September 2017).
In addition, JRODOS computer codes were used by Ukrainian experts in interaction with IRSN and BfS to assess the origin of the ruthenium-106 release in September-October 2017.
In the framework of a EC project (December 2016 – July 2018), the RODOS decision support system was applied in the Chornobyl exclusion zone, which included development of specific models for atmospheric and water transport for the Shelter, ChNPP cooling pond (in the event of tornado) and ISF, forest fires on radioactively contaminated areas etc.

Item 32. Modernization of the SNRIU Emergency Response and Information Centre

The SNRIU Information Emergency Center (IEC) was modernized under an infrastructural project within the Global Partnership Against the Spread of Weapons and Materials of Mass Destruction with support of the Defense Threat Reduction Agency of the U.S. Department of Defense from July 2016 to December 2017. Within the IEC modernization project, the system for communication with NPPs was replaced by modern technologies, power supply system was replaced (including repair of the standby power source, diesel generator), IEC computer equipment and software were updated, etc.

Establishment of a standby emergency center was not considered in this project.

Section 2. Status of Measures Identified upon Stress Tests at Chornobyl NPP

This Section provides information on the status of measures identified upon stress tests at Chornobyl NPP and presented in Table 1.2 of Part IV "Plan for Implementation of Safety Improvements" of the National Action Plan upon Stress-Test Results (2013).

All spent nuclear fuel of the Chornobyl NPP, including damaged one, is currently placed in the SFP of the interim spent fuel storage facility (ISF-1). Therefore, the main efforts of the operating organization are focused on implementation of safety improvement measures at ISF-1. The SNRIU agreed "Decision on Declaration of ChNPP Units 1, 2, 3 as Radioactive Waste Management Facilities in the Decommissioning Process" No. 6-OSE-2016 of 28 September 2016.

Item 1. Installation of an additional level control device in 1 (2) fuel assembly cooling pools-1, 2 for emergencies related to level water decrease below marks 19, 22
Completed (in 2012)
Additional control of water level to prevent its potential emergency decrease is ensured in the spent fuel pools of units 1 and 2.

Item 2. Calculation analysis of buildings of nuclear safety category 1 to determine safety margins and potential failures under loads induced by a tornado of class F 3.0
Completed (in 2016)
The ISF-1 building and overpass structures between the solid and liquid waste storage facility and ISF-1 were examined and certified in 2015. The defects revealed in structures were eliminated during 2016. Calculations of ISF-1 building and overpass structures between the solid and liquid waste storage facility and ISF-1 for a combination of loads including seismic events of 7 magnitudes (which is higher than SSE) and tornado of class F 3.0 have shown that the resistance of ISF-1 load-bearing structures under the above events will be ensured.

Item 3. Calculation analysis of buildings of nuclear safety category 1 to determine safety margins and potential failures under seismic loads
Completed (in 2013)
Calculations of ISF-1 structures related to nuclear safety category 1 testify that ISF-1 SFP civil structures can resist seismic events of 7 magnitudes (MSK-64 scale), while the safe shutdown earthquake for the ChNPP site is 6 magnitudes.

Item 4. Seismic resistance analysis of ISF-1 SFP lining
Completed (in 2013)
Calculations of ISF-1 SFP lining testify that it can resist seismic events of 7 magnitudes (MSK-64 scale), while the safe shutdown earthquake for the ChNPP site is 6 magnitudes.

Item 5. Analysis of stability and potential failures of VS-1 (ventilation stack for units 1 and 2) under SSE and tornado
Completed (in 2014)
Inspections and analyses of ventilation stack VS-1 justified its lifetime extension for 20 years as it will be able to resist a seismic event of 6 magnitudes (safe shutdown earthquake) and a tornado of class F 1.5. This is acceptable because units 1 and 2 are radwaste management facilities.

Item 6. Nuclear safety justification for the spent fuel pools of units 1, 2 with 250×110 mm arrangement of SFAs (as reserve for one ISF-1 compartment)
Completed (in 2012)
Nuclear safety justifications using the burnup credit approach for SFPs of units 1 and 2 allowed determining the arrangement of SFAs in SFPs of units 1 and 2 if emergency unloading of one of the ISF-1 SFP compartments is required.

Item 7. Justifying calculation of the maximum fuel cladding temperature taking into account potential radiological consequences from wet SFA storage
Completed (in 2013)
Additional analysis of fuel cladding cooling in ISF-1 storage conditions was carried out.

Item 8. Development of an action plan to improve the emergency preparedness system in case of beyond design-basis accidents caused by natural hazards, including emergency response measures in case of damage of the building and leakage of SFP
Completed (in 2012)
Emergency notification procedures and emergency response actions in case of potential structural collapse were improved.

Item 9. Amendment of the ChNPP accident and emergency response plan (32P-S) to improve emergency preparedness
Completed (in 2012)
Based on analysis of natural hazards, the ChNPP accident and emergency response plan was revised as appropriate.

Item 10. Development of measures on prompt access of emergency teams from Slavutych by alternative routes in case of damage of Slavutych–ChNPP railroad tracks caused by SSE
Completed (in 2012)
Procedure for delivery of emergency team personnel by motor vehicles from Slavutych to ChNPP (as alternative routes relative to railroad transport) was developed and implemented.

Item 11. Modernization of the ISF-1 radiation monitoring system to ensure neutron flux density monitoring
Completed (in 2012)
Neutron flux density monitoring (within the radiation monitoring system) is envisaged for process rooms and areas for management and storage of spent nuclear fuel.

Item 12. Additional radiation monitoring of exposure dose rate of the container car in ISF-1 during spent fuel transport
Completed (in 2012)
Additional detectors for monitoring of exposure dose rate were installed in the container car storage area in ISF-1 building.

Item 13. Replacement of the UDZhG-04R detector with an RWM-02 detector for the instrumentation channel for monitoring the activity concentration of service water after heat exchangers in ISF-1 spent fuel pools
Completed (in 2013)
Implementation of RWM-02 detector also provides for monitoring of radionuclide activity in service water supplied to ISF-1, thus allowing the contribution of ISF-1 to the total ChNPP discharges to be calculated.

Item 14. Power supply to ISF-1 essential equipment fed from mobile DG
Completed (in 2011)
The mobile DG is placed on the ChNPP site and is ready to be connected to ISF-1 in-house power supply system.

Item 15. Purchase of a new container car for SFA transport
Ongoing.
A railroad container car was delivered to ChNPP for transport of packaging with spent nuclear fuel. Acceptance tests of the container car have be performed. Regulatory review of the documentation package for packaging certification has been completed.

Item 16. Revision of the ISF-1 safety improvement plan
Completed (in 2012)
The ISF-1 safety improvement plan was revised to remove measures that had been already completed and analyzed in the ISF-1 safety analysis report.

Item 17. Introduction of the topic "multiple failures of regular systems and equipment in severe weather conditions" into the 2012 training program for ChNPP staff of certain positions for detailed theoretical elaboration of the training scenario
Completed (in 2012)

Item 18. Introduction of the topic "multiple failures of regular systems and equipment in severe weather conditions" into the 2012 training program (Section 14) for practical exercise by staff of all shifts
Completed (in 2012)

Item 19. Psychological training of staff intended to increase resilience to psychological stress, develop self-control, composure and promote mutual aid and cooperation
Completed (in 2012)
Training on the psychology of actions in extreme situations was introduced on a systematic basis for relevant groups of personnel.

Item 20. Implementation of a system for psychological selection and training of individuals involved in severe accident management, similar to the system for selection of operating personnel
Completed (in 2012)
Psychological examination of emergency team leaders is underway.

Annex. National Action Plan upon Stress-Test Results (2013)